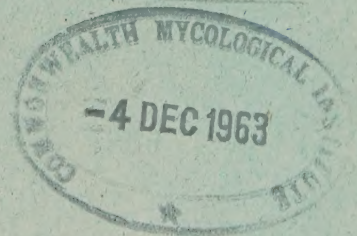
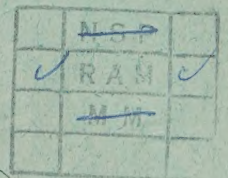




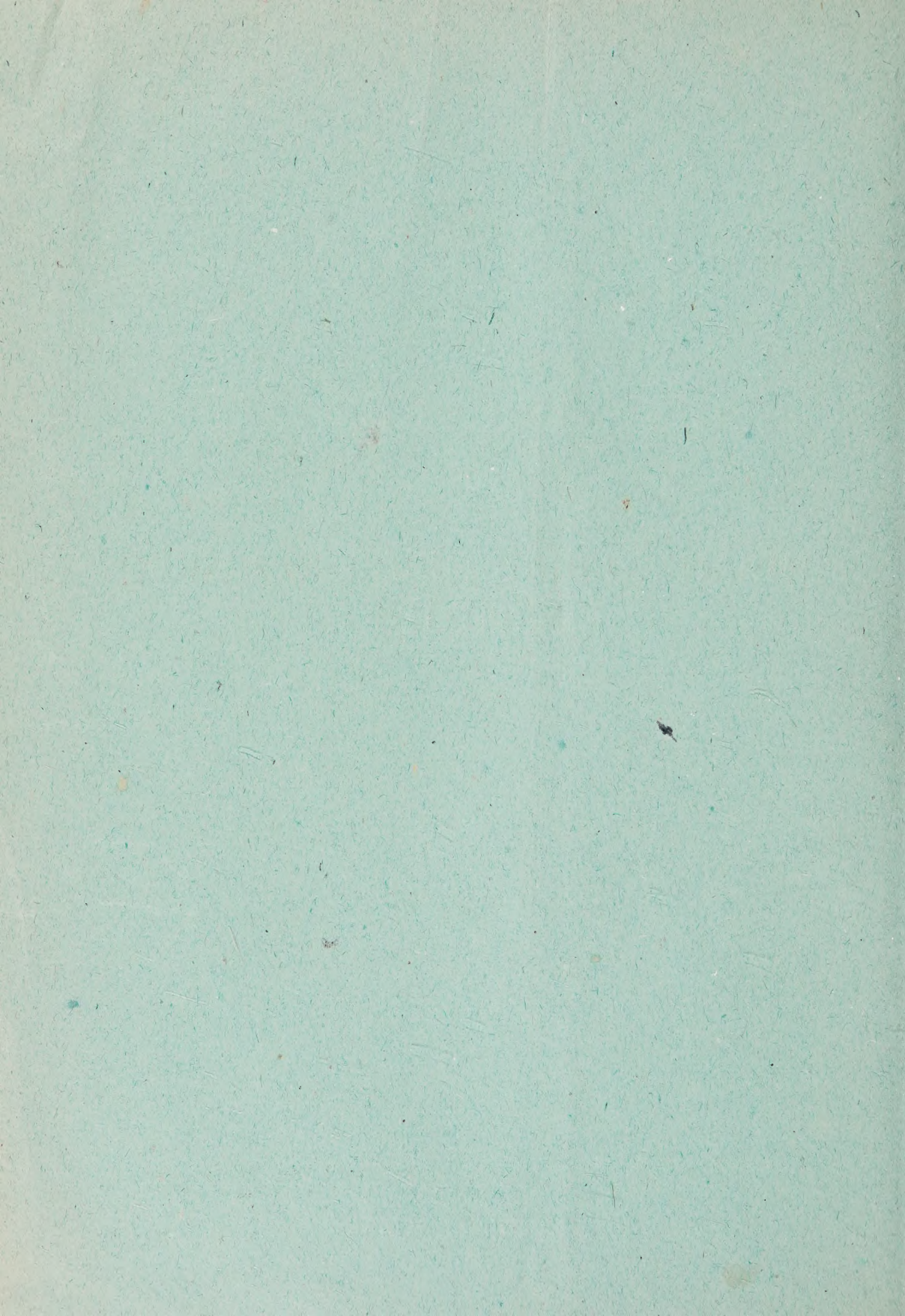
SCIENTIFIC REPORTS
OF THE
INDIAN AGRICULTURAL RESEARCH
INSTITUTE

FOR THE YEAR 1961



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ANNUAL SCIENTIFIC REPORTS OF THE INDIAN AGRICULTURAL RESEARCH INSTITUTE

(1960-1961)

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PREFACE

The Indian Agricultural Research Institute was founded at Pusa in Bihar in the year 1905 by late Lord Curzon, the then Viceroy of India; its establishment was greatly helped by the generous benefaction of an American philanthropist, Mr. Henry Phipps, after whom the main building at Pusa, and later the laboratories of the Division of Soil Science and Agricultural Chemistry at New Delhi, have been named.

The Institute at Pusa started with five Sections under the administrative charge of the Director of the Institute. It was in this home of research, which was then the first and the only one of its kind in India, that pioneering research work was done for nearly three decades by successive votaries of agricultural and allied sciences until the great earthquake of Bihar in 1934. This earthquake was disastrous and the Phipps Laboratory was irreparably damaged. After very careful consideration, it was decided to re-build the Institute at New Delhi which is central and more easily accessible than the remote village of Pusa in north Bihar.

The transfer to New Delhi was completed by the end of October, 1936. Here the Institute stands today, a beautifully laid-out 1100 acre colony about 4 miles to the west of New Delhi railway station. The latitude is $28^{\circ}4'N$, the longitude $77^{\circ}10'E$ and the elevation above mean sea level 750.046 ft. The maximum and minimum temperatures during the year range between $11.5^{\circ}C$ and $41^{\circ}C$ and $1^{\circ}C$ and $34^{\circ}C$, respectively, and the average annual rainfall is about 23 inches, of which about 2-3 inches are received during the winter months. The soil type is predominantly light loam.

In recent years, the Institute has expanded considerably its facilities of experimental fields, buildings and expert staff and it is today looked upon by the Nation as one of the most important sources of expert technical knowledge, advice and instruction in agriculture and cognate branches, and a place for imparting post-graduate training of the highest order. The Institute is under the direct administrative control of the Union Ministry of Food and Agriculture and works in close cooperation with the Indian Council of Agricultural Research which is concerned with promoting, coordinating and financing research schemes on agriculture and animal husbandry in India.

The Institute's Central Library is considered to be the biggest agricultural library in India and one of the best in Asia. The five sections of the Institute, founded at Pusa, have grown into full-fledged Divisions of Agronomy, Botany, Entomology, Mycology and Plant Pathology and Soil Science and Agricultural Chemistry. The Division of Agricultural Engineering was established in 1945 and the Division of Horticulture in 1957. The sections of Agricultural Extension, Agricultural Economics, Plant Introduction and Microbiology have since obtained the status of full-fledged Divisions. In 1958, the All-India Soil and Land Use Survey started functioning as a separate unit of the Institute, under the charge of the Chief Soil Survey Officer. The Institute has under its control a total of 11 sub-stations located all over the country, excluding the 24 regional soil testing laboratories so far established and the centres and sub-centres set up in the country under the Coordinated Maize Breeding Scheme. The overall charge of the Institute vests, since 1945, in a full-time Director, who is assisted by a part-time Joint Director and a Registrar who is the Head of the administrative staff of the Directorate. The Post-Graduate School is looked after by the Dean.

Each of the Divisions except the Divisions of Agricultural Extension, Plant Introduction and Microbiology, is housed in separate buildings, complete with laboratories, glass houses, workshops and research and auxiliary staff.

The Library has in its possession over 150 thousand books and about 12 hundred periodicals. Eighty-six new periodicals were added during the year.

(ii)

The Division of Agronomy has bred and maintains a Sahiwal herd of milch cows and in the Division of Botany an extensive living collection of crop plants and related species have been built up. With the establishment of a Gamma garden with its powerful two thousand curie source of radio active cobalt 60, the programme of mutation research in the Division of Botany has been intensified. In the Division of Entomology a valuable National Pusa Insect Collection and in the Division of Mycology, Herbarium Cryptogamae Indiae Orientalis and the Indian Type Culture Collection of Fungi and Bacteria are being maintained. The Radio Tracer Laboratory is attached with the Division of Soil Science and Agricultural Chemistry where the Cartographic Laboratory and the coordinating centre of the All-India Chain of Soil Testing Laboratories is also located.

Reference has been made in previous reports to the pioneering work done at this Institute by several eminent scientists in different subjects. In recent years the most notable achievement of the Institute has been the production of a series of improved disease-resistant wheat varieties (now well known as the New Pusa or N.P. wheats).

Besides the regular programme of research, various Divisions of the Institute undertake a number of research projects financed either by the Ministry of Food and Agriculture itself or by bodies like Indian Council of Agricultural Research. This includes, besides several others a project on All India Trials and Fertilizers and Land Use, a Coordinated Maize Breeding Scheme dealing with research on hybrid maize. In recent years the Institute has been entrusted on an increasing scale with the coordination of research projects on regional basis and in several such projects, it is receiving excellent cooperation of foreign organisations like the Indo-U.S. Technical Cooperation Mission and the Rockefeller Foundation. Work on Delhi intensive cultivation scheme has now been extended to the whole of Kanjhawala block and is being looked after by the newly established Division of Agricultural Extension assisted by the experts from the different Divisions. Post-Graduate training constitutes an important part of the Institute's activities. The two-year Diploma course leading to the Associateship of the Institute which was being given since 1923 was reorganised in 1958, when a Post-Graduate School was set up with the generous cooperation of the Rockefeller Foundation, and the Institute was accorded the status of a University for organising courses of instruction leading to the award of M.Sc. and Ph.D. degrees in agricultural sciences. The system is very much on the line of the post-graduate system in vogue in the American Universities with such modifications as were deemed desirable to suit conditions in India. Hostels attached to the Institute provide residential accommodation to about three hundred students. The Institute is frequently visited by a large number of dignitaries, administrators, scientists and farmers, from within the country as well as from abroad. There has been appreciation with regard to availability of research facilities and out-put of scientific work in different spheres of agricultural improvement by the Institute.

REPORT OF THE DIRECTOR

1. INTRODUCTORY

During the year under report further progress was made in the research activities, training programme and extension work of the Institute. Several new projects sanctioned under the Third Five Year Plan started functioning. The establishment of a phytotron would be a great help in conducting experimental work under controlled climatic conditions ; full use is being made of the Gamma Garden and this unique facility for field radiation with gamma rays has been made available to all interested scientists in the country. The construction of a building for the Cereal Research Laboratory for which considerable milling, baking and cereal-testing equipment has been provided by the Indo-U.S. Technical Cooperation Mission, has been completed. The building to house the Division of Horticulture is ready and is expected to be occupied in the near future. In addition, buildings for the laboratory for fundamental plant genetical research, Insectary, extension to Mycology Division and the Assembly Hall were almost completed during the year. Plans for the construction of laboratories for the Division of Agricultural Extension and Microbiology have been approved. The research work on hybrid maize reached an advanced stage and some flint type of double cross hybrids developed at the Institute have been released for seed production on a large scale.

The Post-Graduate School, in the organisation and operation of which the Rockefeller Foundation have given considerable assistance, continued to make steady progress. Dr. A. B. Joshi was appointed as the Dean of the School. The Rockefeller Foundation also made available to the School the services of several eminent scientists as Visiting Professors. The I.A.R.I. Library has been strengthened under the School by the appointment of a Senior Class I Librarian and a Junior Class I Documentalist.

The fifth in the series of research reports for the benefit of research workers in the country was issued by the Institute during the year under report. It deals with "Prevalence of Physiologic races of wheat and barley rusts in India during 1952-57".

Dr. R. V. Tamhane, Head of the Division of Chemistry, relinquished charge of his post on 4-4-61 ; Dr. S. P. Raychaudhuri, Chief Soil Survey Officer, on 14-8-61 ; Dr. R. D. Verma, Agronomist, on 6-11-61 ; Shri S. L. Vishnoi, Professor of Agricultural Extension, on 25-7-61 and Shri H. N. Batra on 27-12-61 to take up other appointments. Their departure is a great loss to the Institute. Dr. S. K. Mukherjee was appointed Head of the Division of Horticulture from 21-4-61 ; Dr. S. V. Govindarajan, Chief Soil Survey Officer from 14-8-61 ; and Dr. M. S. Swaminathan, Head of the Division of Botany from 1-12-61. Shri H. B. Singh joined the supernumerary post of Plant Introduction Officer from 8-8-61 on merit promotion.

Dr. S. P. Raychaudhuri, Virus Pathologist, was appointed Professor of Plant Pathology on 2-8-61 and Shri R. L. Munjal, Systematic Mycologist from 10-1-61 in the Division of Mycology and Plant Pathology. In the Botany Division, Dr. S. V. S. Shastri was appointed as Botanist at Pusa from 21-3-61, Dr. R. L. Paliwal as Senior Maize Breeder from 23-3-61 and Dr. B. R. Murthy as Geneticist from 30-8-61. Dr. Vishnu Swarup joined as Geneticist in the Horticulture Division.

Shri V. S. Bendre joined as Dy. Registrar on 18-3-61 and Shri S. P. Phadnis was appointed as Librarian from 8-12-61.

Of the regional centres of the Expanded Soil Testing Scheme, the control of Centres at Jodhpur, Hazaribagh, Agartala and Ballehunur was transferred to the respective State Governments.

2. SUMMARY OF MAIN RESULTS OF RESEARCH

Agronomy

1. Soil Fertility.—Application of phosphate to berseem at 64 lb. P_2O_5 per acre as farmyard manure or superphosphate, singly or in combination, was conducive to higher production of both fodder and seed. The residual phosphorus effected significant increase in the yield of the green fodder of cowpeas grown in rotation with berseem.

In a cereal rotation wheat—maize, highest yield per annum was obtained when each of the crops—wheat and maize—was fertilised with 40 lb. N per acre.

At Pusa, Bihar, *Arhar* (*Cajanus cajan*) indicated a marked response to phosphate fertilisation under rainfed conditions. Wheat yields were appreciably increased by *sannhemp* green manure fertilised with phosphate at 80 lb. P_2O_5 per acre as compared to green manure alone or direct application of NPK or NP to wheat.

At New Delhi, wheat, barley, *bajra*, *jowar* and *guar* responded to fertilisation under rainfed conditions. For the same amount of money invested in fertilisers, barley in *rabi* and *jowar* in *kharif* were the most responsive to fertilisation and most remunerative crops under local conditions.

Field trials on spray fertilization showed that gram under rainfed conditions and wheat and berseem under irrigated conditions made more efficient use of phosphorus than from soil application. Studies with berseem indicated that fertilizer economy can be effected if part of phosphorus is applied through soil and spray application. Urea nitrogen applied $\frac{1}{2}$ through soil and $\frac{1}{2}$ through spray increased the yield and improved the protein content of wheat.

2. Field Crops.—In a cultural-cum-fertiliser trial at Karnal, wheat showed no differential response to cultivation by tractor or bullock-drawn implements. Application of nitrogen and phosphorus at 30 lb. per acre effected significant increase in the yield. On equivalent nitrogen basis (60 lb. N), a combination of ammonium sulphate (30 lb. N) and farmyard manure (30 lb. N) was superior to either of them alone or to green manure. Transplanting of the six New Pusa varieties of wheat indicated that variety N.P. 718 yielded the highest followed closely by N.P. 824 at Karnal whereas no significant difference in yield was observed at New Delhi. Nursery sown on 18th October and transplanted after 30 days with a spacing of 10" × 10" were other treatments that increased wheat yield significantly. Linseed varieties N.P. R.R.9, N.P. R.R.38 and N.P. R.R.45 did not show any significant difference amongst themselves. Higher seed rates (20 lb./acre) and nitrogen levels (40 lb. to 80 lb./acre) gave increased yields. The optimum fertilizer dose for maize hybrid U.S. 578 was found to be 110 lb. N, 30 lb. P_2O_5 and 40 lb. K_2O per acre. Likewise, a dose of 80 lb. N per acre applied in three splits (at sowing, knee high and pre-tasselling stages) was found to be optimum for Texas 26. This variety showed a significant response to zinc fertilisation.

3. Vegetable Crops.—Cauliflower, peas and turnip responded significantly to applications of farmyard manure at 2.5 to 5 tons per acre. Only cauliflower showed an added response in yield due to nitrogen and phosphorus application in the form of artificial fertilizers. Turnip was responsive only to potassic fertilization.

4. Weed Control.—The broad-leaved weeds in wheat are quite effectively controlled by 2, 4-D (Sodium salt) sprayed at the rate of 6 oz. (acid equivalent) per acre four weeks after sowing. Maximum eradication of nut-grass (*Cyprus rotundus*) and highest yield of the following wheat crop were obtained when hot and rainy weather cultivations were supplemented with deep spray of 2, 4-D at 4 lb. per acre. Pre-emergence application of Simazine at 2 lb. and post-emergence application of 2, 4-D at 12 oz. per acre was as effective as four times hand weeding in maize. Pre-emergence application of Simazine

at 4 lb. per acre to sugarcane field with and without 2, 4-D (post-emergence application) and cultural treatments controlled the weeds and enhanced the crop yield appreciably over the unweeded crop.

5. Irrigation Experiments.—Potato and sugarcane responded to frequent irrigations at low soil moisture tension (below 1.3 atmosphere). Peas gave the best yield with three irrigations and wheat with two irrigations. The transplanted rice crop irrigated at field capacity gave as high yield as the one where varying depths of water were maintained. The draining of standing water followed by replenishment with fresh water did not produce beneficial effects.

6. Fodder Crops.—Pusa Giant Napier Hybrid, a cross between *Pennisetum purpureum* and *Pennisetum typhoides*, was found to outyield its parent Napier in the preliminary trials. Napier, Setaria and Para grasses showed increasing response to nitrogen levels upto 160 lb. N per acre.

7. Sahiwal Herd.—In the Sahiwal herd, 62.6% of the cows were in milk. The milking and overall averages were 22.7 and 14.4 lb. per day per cow respectively. The average milk yield of 20 cows which completed their lactation was 7322 lb.; 6 cows gave more than 8,000 lb. each in 306 days. The average age of 11 heifers at calving was 2 years, 10 months and 24 days. Three Sahiwal bulls and one Murrah buffalo bull were sold.

8. Agricultural Statistics.—Sampling units of 4 feet length with two cuts per row from at least 6 rows of wheat per plot indicated a sampling error of 5 per cent. in the estimation of wheat yield.

9. Agricultural Economics.—With increase in size of holdings, the size of family labour tended to increase although the availability per acre declined sharply. Studied in the same order, while investments in fixed capital rose, the value of the investments per acre declined. As the farm size increased, gross expenses tended to decline while net return, family labour income and farm business income rose. Farm Business studies on cultivators' holdings also revealed an integration of productivity of milch stock and their feeding standards at a rather low level. In general, holdings less than 15 acre size failed to provide a proper balance between land and livestock on the farm. The cropping intensity ranged from 140% in the smallest holdings to 122% in the largest; at the same time, the percentage of cropped area under *bajra* tended to decline while that under wheat and gram registered a rise.

Agricultural Engineering

1. Bullock Drawn Seed-Drill.—Based on a design received from the T.C.M., Greece, a 4-row multipurpose seed-drill has been developed. Field trials showed satisfactory performance. The seed rate used for wheat was uniformly maintained at 35.6—36.4 kilo/acre. The draft recorded was 170-180 lbs.

2. Two-row Groundnut Planter.—A two-row groundnut planter has been developed on the basis of a single row model designed earlier by this Division, and has given satisfactory results. Action is in hand to get six of these machines fabricated with a view to get them tested under different soil and climatic conditions in the country.

3. Animal Drawn Disc-Harrow.—An animal drawn off-set disc-harrow has been designed and constructed. During the preliminary trials, it was found that it was capable of working in the local soil conditions to a depth of about 4" with an effective working width of 36". The draft was only 250 lbs. and the output was over 2½ acres in 6 to 8 hours.

4. Hand Hoes.—A novel design of a multi-purpose hand hoe, manufactured in the Division, has evoked considerable interest. An application for patent has been filed and negotiations are being undertaken by N.R.D.C. for its large scale manufacture.

5. Investigations of Water Logging Problems at the I.A.R.I.—The project was started in May, 1958. Periodical checks of water levels of all the wells in the IARI Estate and the effects and water carrying capacities of surface drains were being studied and a new method of ascertaining the hydraulic gradient was also evolved.

6. Design, Installation and Evaluation of Tile Drainage Project.—This project has been undertaken in collaboration with the Rockefeller Foundation. Water table observations are taken at fortnightly intervals. In addition, construction work for shaping of open drains and laying out more tile lines has been undertaken.

During 1961 Tile Line No. 4 and an 80 ft. portion of Tile Line No. 3 in Shadipur area were constructed which resulted in substantial improvement in sub-soil water as well as surface drainage in Block No. 4 and Shadipur area as compared to other fields. The water table in the tiled area has been lowered to a depth of 6 ft., which is $2\frac{1}{2}$ ft. lower than the control plots.

7. Water Measuring Devices For Efficient Irrigation.—A number of water measuring devices were studied in order to evolve an accurate and simple measuring device and the most promising device was the convergent-divergent type flume. A 3" parshall flume was fabricated and tried in the fields with success. 6-3" flumes were introduced in IARI estate.

8. Test of Labour Tractor.—A 5 Horse-Power Labour Walking Tractor made in France was tried in the Institute Farms at the instance of M/S Ghaziabad Engineering Co. Ltd., New Delhi. The tractor was supplied with a two way plough, a three tined cultivator, a 2 row planter, a mower and a set of blade hoes. All the implements except the planter, which was studied in the workshop, were put to field tests. The tractor was worked for a total of 32 hours. The quality of work done in various field operations was appreciably superior to that of the bullocks. It is, however, felt that the tractor in its present form would not be very useful under the Indian conditions.

9. Single Bullock Harness.—With basic data taken from a recent F.A.O. publication, a three-pad harness was fabricated and tried in the field. The harness which is cheap, is made mainly of two wooden shoulder hames and three leather or canvas pads. The results have been encouraging. In field trials, one large-sized bullock was able to record a pull of 400 lbs. with this improved hitch which enables animal's body weight to be used more efficiently.

Agricultural Extension

In a project to find out "Relative effectiveness of various extension techniques in teaching rural youths in improved calf rearing" it was revealed that the combination of four extension methods (group discussion, method demonstration, flash cards and literature) was most effective in bringing about change in behaviour of the youths. Moreover, the first exposure was the most effective in bringing about the result. Age had pronounced and significant effect on the attitude of youths. The most receptive age was between 15 and 20 years. Education and economic status of the youths were positively correlated with the acceptance of innovations.

In a study to find the influence of socio-economic factors on acceptance of the cow-dung gas plants by the farmers of Kanjhawala Block, it was observed that literacy had no influence on the change of behaviour of farmers towards cow-dung gas plant. But, the income or status of the farmer played a positive role with the change in behaviour. Findings of this study also confirm that age was no barrier in the acceptance of the innovation.

An investigation entitled "Effectiveness of exposures and extension methods" in motivating the milk producers of Delhi villages for organising milk selling cooperatives" was carried out. The findings of this study are two fold. First, with the increase of number of exposures to the recipients the change in behaviour also increased. Secondly, personal contacts and group discussions proved the most effective tools in motivating the farmers towards the adoption of milk sale cooperatives.

The data of 'Result Demonstration' which were laid out in villages under irrigated condition during last *rabi* were analysed. It appears from the statistical analysis that the differences between N.P. 823 and N.P. 824 varieties of wheat were not significant but both of them were significantly superior to N.P. 718.

Transplanting of Wheat.—Due to heavy and late rains sometimes, the land in large parts of Kanjhawala Block remains wet till winter making *rabi* sowing ineffectual. An innovation to solve this problem was demonstrated to farmers during the year. Wheat variety, N.P. 823, was raised in a nursery and then transplanted, in village Nilothi. The yield obtained through this practice was 21.5 mds. per acre. The transplanting was done on the 21st December, 1961. In another plot where the crop was sown about the normal time the yield obtained was 13.5 mds. per acre. This practice has further been demonstrated during the current season in 4 other villages under water-logged condition. In 3 such demonstrations, boron was also applied to boost the yield further.

Chemical weeding with 2, 4-D for the effective eradication of weeds, which has been demonstrated for some time in villages, has caught the imagination of the farmers.

A programme of Intensive Cultivation for upgrading agriculture in the 56 village of Kanjhawala Block was launched by the Indian Agricultural Research Institute during *rabi* 1961. As a result of this programme ten seed farms, one in each V. L. W's circle, were established. These farms will serve as 'whole farm demonstration' for the cultivators of the neighbourhood. They will include all essential innovations concerning a single farm enterprise.

The base-line data for the Bench Mark Survey Scheme launched in Kanjhawala Block have been collected. The approximate ratio between agricultural and non-agricultural families in the block comes to 2 : 1 ; between gross area and double cropped area, 7:1 and between area under improved and indigenous seeds, 1: 3.

Botany

1. PLANT BREEDING AND GENETICS

(a) **Wheat.**—The variety N. P. 825, one of the improved types of the "N. P. 800 series", recently evolved in this Division was tested in the regional trials for third year running and observations based on 21 of these trials indicated that this variety promises to replace several of the existing types in cultivation in Uttar Pradesh. Its yield performance in most of the trials was found to be very impressive in comparison with the controls which included such well known varieties as C.13, C.273, C.281, C.591, R.S.31-1, N.P.718 and N.P. 720. Furthermore, N.P. 825 performed very well also in northern Rajasthan and has consistently out-yielded Pb. C.591, the recommended variety for this region. Another variety of this series, N.P. 832, developed at the Indore Sub-station of the Division and tested in numerous yield trials was found to be superior to local *pissi*, the variety extensively cultivated at present in the Malwa region. This variety has been bred by hybridising *pissi* local with a black rust resistant Kenya wheat and combines in it considerable tolerance to rust attack, large grain size and high protein content.

(b) **Hybrid Maize.**—The first phase of the experimental work under the Co-ordinated Maize Breeding Scheme for which this Division is the main co-ordinating centre, culminated in the release of four Indian double cross hybrids for large scale seed production and demonstration. These four hybrids named Gunga Hybrid Makka No. 1, Gunga Hybrid Makka No. 2, Deccan Hybrid Makka and Ranjit Hybrid Makka, have, unlike similar American hybrids, flint (hard) type of grains which are preferred in India. The yield of these hybrids at the recommended level of fertilizing is nearly 50% more than that of the local variety. Furthermore, the new hybrids show greater tolerance to diseases and pests than either the local varieties or the dent-grained American hybrids. The first two of these hybrids have been developed for the Indo-gangetic plains, the third for peninsular India and the fourth for south Rajasthan, Gujarat, and Maharashtra.

(c) **Bajra** (*Pennisetum typhoides*).—Improved Ghana, a new bajra variety developed at this Division from seed material introduced from Ghana, gave about 23% higher yields than Punjab type 55, the variety currently recommended for cultivation in Delhi State. Improved Ghana is as early in its maturity as Punjab T. 55 and has markedly attractive grains of bold size. The variety was released for demonstration trials in some parts of Delhi State and for yield trials in neighbouring States of Punjab, Rajasthan and Uttar Pradesh.

(d) **Cotton.**—Investigations were in progress to improve the staple length and ginning out-turn of the Punjab *hirsutum* variety H.14. These studies have yielded several promising selections showing improved halo-length and ginning outturn.

(e) **Forage plants.**—Two experimentally produced species hybrids have given, in preliminary experiments, very promising performance with regard to forage yield. The first of these hybrids obtained from a cross between elephant grass (*Pennisetum purpureum*) and cultivated bajra (*P. typhoides*), with its strikingly high yield, compares favourably with the forage parent in its nutritive value and palatability. The second hybrid, obtained from the cross between an indigenous strain of the common anjan grass (*Cenchrus ciliaris*) and a related species from America (*Pennisetum ciliare*) has out-yielded the American parent, the better yielding of the two parents, by nearly 100%. The hybrid produces soft good quality forage and its effective growth is during the period from April to June when the parental species remain relatively dormant.

(f) **Vegetables.**—The utilization of male sterile mutants of tomato, particularly of the close anther type, was in progress for the exploitation of hybrid vigour. Thirty-three hybrids produced with the use of these male sterile lines, were tested for their performance in relation to the 15 parental varieties. Some of the hybrids out-yielded the superior parental variety by as much as 40% or more.

A hybridization programme involving *Pusa Sada-Bahar*, a hairy-podded variety of vegetable *guar*, suitable for growing in more than one season and *Pusa Mausami*, a smooth podded variety, which can be grown only during the rainy season, has resulted in the evolution of two smooth and long-podded promising lines, which out-yielded *Pusa Sada-bahar*, by a considerable margin.

2. CYTOLOGY AND CYTOGENETICS

(a) **Performance of induced awned mutants of wheat.**—The yielding ability of the fully awned mutants, isolated from the irradiated population of the awnless wheat varieties N.P. 797, N.P. 799 and N.P. 809, was again tested in a number of trials conducted at Delhi as well as at some of the sub-stations of this Institute. The awned mutants of all the three varieties continued to maintain their superiority, some of them out-yielding the parental variety by as much as 40%.

(b) **Interspecific hybridization in Jute.**—The F_3 progeny of the cross between *Corchorus olitorius* and *C. capsularis* reported last year as also the F_3 progeny derived from another cross between these two species, have been studied for the segregation of various characters and for the chromosomal basis of the differentiation of the two species. The segregation for all the characters differentiating the two species was found to be skewed in the direction of *olitorius*. Aberrations such as unpaired regions and inversion loops at pachytene, a heteromorphic bivalent at Metaphase I and a dicentric bridge and acentric fragment at anaphase I, were observed in several of the F_2 plants. These cytological observations and the occurrence of a high proportion of unthrifty and inviable seedlings as well as the skewed segregation, indicate that the genomes of the two species have differentiated in the direction of increased coherence which automatically decreases the possibility for effective interspecific recombination. From the breeder's point of view, the occurrence of several trisomic plants in the hybrid progenies appeared promising, since a way is thus opened for substituting whole pairs of chromosomes that cohere but do not recombine.

(c) **Mutation Studies in Ornamental Plants.**—X-ray treatment of seeds of *Cosmos* has resulted in the production of a double-flowered mutant in which the anthers are completely replaced by petals making the inflorescence much more attractive. There was evidence that the mutation conditioning this, rather rare, flower form, is of a dominant nature. This finding is of practical interest for it suggests the possibility of developing a strain which would have half of its plants producing double flowers, unlike similar strains of other winter annuals like *Petunia*, in whose case the recessive nature of the gene controlling the double flower form reduces considerably the progeny of double plants in the segregating populations.

3. CROP PHYSIOLOGY

Studies on Drought Resistance.—By slightly delaying the sowing of the wheat variety, Pb.C.281 (in comparison with another wheat variety N.P. 720) under pot culture, its ears were made to dehisce later and its grains to develop at a slightly high temperature. The grain weight per ear of Pb.C.281 was equal to and higher than that of N.P. 720, under normal water supply and drought respectively. The rate of yellowing of the ear of Pb.C.281 was not materially hastened at higher temperature thus indicating its greater resistance to atmospheric and soil drought from the functional point of view.

4. PLANT INTRODUCTION AND EXPLORATION

The Plant Introduction Organization continued to procure from all over the world plant material which could be directly or indirectly utilized to meet the agricultural needs of this country. A total of 3,299 samples of seeds and planting materials were imported from foreign countries, and a particularly striking introduction was that of the Australian oat variety 'Kent' which yields grains of the desired milling quality for the break-fast food industry. This newly started industry in India has been faced with considerable difficulties on account of the non-availability of local material of desired quality.

Exploration Expedition to Central Nepal.—An interesting collection of plants and planting material, fungi and insect specimens was made during an exploration expedition to Central Nepal organised during the year by the Organization. The members of the expedition surveyed the area between Butwal and Pokhara and between Pokhara and Muktinath covering an altitude range of 1,200 to 12,000 ft. above sea level. The botanical collection comprising over 400 living items and 500 herbarium specimens, included cultivated forms and wild relatives of wheat, barley, oats, linseed, essential-oil-yielding plants, prunes, pears, persimmon, berry fruits, wild species of grapes, roses, jasmines, medicinal and forage plants.

5. FUNDAMENTAL GENETICS LABORATORY

(a) Fundamental studies on distant hybridization in the genus *Sorghum* have yielded fruitful results. A large number of useful interspecific hybrids have been successfully made for the first time in this genus. Karyomorphological studies of several species led to the identification of 10 pachytene bivalents, for the first time, in each of these *Sorghum* species. Cytogenetical analysis of many species hybrids in this genus gave very interesting results. It has now become possible on the basis of these results to correct several existing anomalies in the classification of these species and to throw more light on the cytogenetical mechanisms underlying species differentiation in this economically important group of crop plants.

(b) A hypothesis, based primarily on cytogenetical considerations rather than biometrical, has been suggested in relation to the genetic control of quantitative characters. It is concluded on the basis of these considerations and evidence relating to the nature and organisation of genetic material and biochemical understanding of gene action, that both qualitative and quantitative variation can be interpreted with the genes of the same class acting in conjunction with the genetic background and the environmental effects. From the breeder's point of view, this suggestion has important implication for it brings out some serious limitations of the existing methods of analysis and indicates several new lines for further work in this field.

Horticulture

I. FRUIT SECTION

(1) **Mango.**—The performance of *Neelum*, a South Indian commercial variety was found to be promising under Delhi conditions. Preliminary trials have demonstrated the feasibility of veneer grafting (grafting with detached scion), as a method of mango propagation. Application of N.A.A. (100, 200 and 400 ppm.), M.H. (200 and 400 ppm.) increased the production of hermaphrodite flowers in var. *Janardhan Pasand*. There was an indication of partial self-incompatibility in the variety *Dashehari*.

(2) **Citrus.**—In sweet orange (var. *Hamlin*), positive correlation between the number of flowers to leaf area and extension growth was noted. Chemical composition of shoots carrying fruits to maturity, showed that the total dry matter content of all the flushes during early spring was highest, in comparison to other sampling dates. In mandarin, (var. *Nagpuri*), the behaviour of fruiting and non-fruiting shoots revealed that individual shoots had a tendency towards alternate bearing. Active period of bloom, bud differentiation was found to extend over a fortnight from the last week of January. Similarly in Marsh Seedlees variety of grapefruit, trend towards alternate bearing of individual shoots could be discerned. As in sweet orange, positive correlation between leaf growth and number of flowers was obtained in Marsh Seedlees variety. Sweet lime also showed alternate bearing, in respect of individual shoots. Studies on fruit drop in mandarin suggested that fruit shedding could be checked, by application of 2, 4-D (15 and 20 ppm.) and 2, 4, 5-T (5 and 10 ppm.).

(3) **Grape.**—Fresh introductions were made from Florida and California, bringing the progressive total to 174. *Bharat Early* and *Gros Colman* proved to be quality varieties, while *Bhokri*, *Kandhari* and *Black Muscat*, were again found to be early maturing varieties. Preliminary studies on pollination have indicated the possibilities of induction of male sterility by the application of chemicals such as MH, TIBA and FW 450.

(4) **Loquat.**—Complete self-incompatibility was evident in the variety *Improved Golden Yellow*, while in other varieties, it occurs in varying degrees. The variety *California Advance* proved to be the best pollinizer for the two varieties *Improved Golden Yellow* and *Pale Yellow*.

II. VEGETABLE SECTION

(1) **Tomato.**—A selection was found to be resistant to root-knot nematode under laboratory and field conditions and is suitable for recommendation to infested areas. Inheritance studies revealed that two factors (R and T), determined the fruit skin colour. The green stem-end colour in mature fruit was dominant over uniform colour. Similarly non-cracking character of the fruit base, was found to be dominant over distinct cracking feature. Linkage was shown to exist between genes for fruit skin colour and fruit flesh colour. Physiological studies with plant regulators (2, 4-D, CIPA, GIB, No. A) showed that seed treatment and whole plant spray significantly increased the yield at various concentrations. Plant tissue analysis indicated that the uptake of nitrogen was significantly higher in seed treatment.

(2) **Cole Crops.**—In cauliflower, yield trials with 17 late varieties have demonstrated the superiority of Snowball-16, the present recommended variety. In cabbage, similar trials suggest that the standard variety Golded Acre was superior. In another trial, an exotic variety Glory of Enkhuyenze produced bigger heads than the standard variety.

(3) **Cowpea.**—The previous year's findings were tested again, in respect to the efficacy of plant regulator applications. It was found that MH at 15 ppm. and 2, 4-D at 3 ppm. when sprayed in the pre-flowering stage increased the pod yield by 28 and 26 per cent. respectively over the control.

(4) **Watermelon.**—Studies were made on the experimental modification of sex-ratio and yield; TIBA at 100 and 200 ppm. produced significantly more female flowers and consequently increased the yield. In watermelon, seven varieties emerged promising from the yield trials, they were New Hampshire Midget, Rhode Island Red, Early Sunrise, *Asahi Yamato*, *Fuken Mudirigo*, *Nugaoka Kohai* and Russian.

III. FRUIT AND VEGETABLE PRESERVATION SECTION

(1) **Canning.**—Varietal studies in garden pea, showed that Bonneville, Early Giant, Yates Early Crop and Duke of Albany were suitable. In Litchi, *Bedana* and *Dehraduni* were found to be good canners while *Longia* was unsuitable.

(2) **Preserves.**—Studies were conducted on 15 strains of yeast, isolated from commercial samples of apple preserve. In *Amla* preserve, pretreatments like oaking, puncturing and blanching were found to be responsible for heavy losses of vitamin C and tannins.

(3) **Juices and Beverages.**—Investigations with mandarin juice showed that freezing in tin cans was best for retaining colour, odour, taste and vitamin C. Two strains of yeast and three of mould isolated from spoiled products were identified. The mould spores were found to be more resistant to chemical preservatives *viz.*, SO₂, Sodium benzoate, sorbic acid than yeasts. Studies on fortification with vitamin C, of different juices and squashes have shown that natural vitamin C was better retained in storage than synthetic ascorbic acid. Addition of 50 mgm. ascorbic acid per 100 gm. of orange juice and 100 mgm. for other products, is recommended for general improvement of the quality.

IV. FLORICULTURE SECTION

Fifty eight rose varieties belonging to all classes including different species of *Rosa* were introduced from various countries taking the progressive total to 664. Seedlings No. 7 and No. 24 have been found to be promising. Observations on the bud sport of *Madame Driout* and *Beryl Ainger* confirmed the change of flower colour.

V. VEGETABLE BREEDING SUBSTATION KATRAIN

(1) **Vegetable work.**—In turnip, and carrot selections were made resulting from the crosses of Asiatic and European varieties. In beet and *palak*, selection work is being carried out in the crosses between multigerm and monogerm varieties for combining monogerm character with economic characters in the two crops. Heterosis investigations in six varieties of drum-head types of cabbage, were conducted with diallel analysis technique. In general hybrid vigour was found to be manifested in terms of larger sized heads and higher yield. Complete dominance was observed in the number of marketable heads, net weight of heads and maturity, while over dominance was present in yield. Non-allelic interaction particularly of complementary nature was observed in all the characters. In case of maturity there was a pronounced additive gene effect with only a slight indication of gene interaction. Heterosis breeding seems to be promising for improving the economic characters in cabbage. Studies were continued in X_2 progenies of French bean and interesting mutants were observed.

(2) **Floriculture work.**—Collection of different varieties in some annuals were made. Similar collections in bulbous plants—Daffodils, Narcissi, Tulips, Hyacinths, Freesia and Gladioli—were made. Work has been initiated in collection of varieties of Azalea, Camellia, Hydrangea and Fuchsia.

(3) **Seed multiplication.**—A total quantity of 1155 kilograms of nucleus seeds of different kinds of vegetables was produced.

Entomology

I. TAXONOMY

Six specimens of coreid, *Carvelhora arecae* Miller and China and two specimens of the curculionid, *Meionops glaucinus* Marshall were identified and added to the National Pusa Collection. A new aquatic weevil infesting *Trapa bispinosa* Roxb., was described as *Bagos trapae* sp. n. Two more curculionids *Nassophasis albomaculatus* sp. n., and *Apion tamarixus* sp. n. were discovered and described as new to science. Two new species belonging to Tenebrionidae were described as *D. mayae* sp. n. and *Palorus shikhae* sp. n.

II. INSECT PARASITOLOGY

It was estimated that 26 samples of 20 larvae each, would be required to give a reliable estimate of *Vipio deesae* (Cameron) population when 6.8% of the sugarcane top-shoot borer larvae were found to be parasitised.

When females of *Chelonus rufus* Lyle were offered 35 eggs of *Corcyra cephalonica* Stainton each day till death, the distribution of progeny was almost uniform during the first three days. It was erratic from 4th to 8th day with heavy superparasitism.

Study of malformed mango shoots and soils around mango trees revealed the presence of *Typhlodromus* sp., *T. nesbitti*, *T. rhenanus*, *Cheletogenus ornatus* and some Aecosejids.

Laboratory experiments showed that at low parasite density and high or low host density, *B. brevinornis* was intrinsically superior to *B. gelechiae*.

A *Bracon* sp. was found to parasitise about 9% Rice Hispa in Madhya Pradesh. Two genera of parasites (*Praon* and *Ephedrus*) were recorded for the first time from the Indian Union.

III. ECOLOGY AND TOXICOLOGY

Ecological studies on *Phadka* indicated maximum emergence of nymphs about 10 days after the onset of monsoon. The nymphs continues to live on the bunds for 10-14 days after emergence. Dusting of bunds with 2.5% BHC effectively controlled the pest

Studies on the development of *Trichogramma evanescens minutum* Riley showed no development during April-June when the maximum temperature was above 35°C for 6-14 hours daily.

A mutant of *Dysdercus koenigii* (Fabr.) which could be distinguished from the normal red form in possessing grey colour during the nymphal stages and ochraceous in the adult stage, was observed in the laboratory. Genetic analysis of colour variation showed that it was a recessive mutation involving a single gene, the red being dominant over grey.

Kelthane and Trithion were found to be effective as ovicides against the sugarcane mite.

Second Five-Year Plan Schemes :

Sufficient radioactivity in the adults of *Bracon brevicornis* Wesm., was obtained without adversely affecting their general behaviour by rearing them on caterpillars with radioactivity ranging from 4500-8000 c.p.m. The caterpillars were made radioactive by allowing them to feed on P^{32} mixed crushed 'jowar'. Biological half-life of P^{32} in the parasite was found to be seven days.

2-n-amyl-3-piperonyl acrolein tested against *Tribolium castaneum* adults was found to be effective as synergist of pyrethrins when used in the ratio of 9:1.

Pronounced gustatory repellent effect of neem seed suspension was observed against the adults of *Schistocerca gregaria* and *Locusta migratoria*.

Semisynthetic diets consisting of different combinations of dry cabbage leaf powder, wheat bran, whole milk powder and Brewer's yeast indicated that the rate of growth of *Schistocerca gregaria* fed on cabbage leaf powder, wheat bran and Brewer's yeast (2:2:1) was much near to those fed on fresh cabbage leaf.

Studies on the development of *Trogoderma granarium* Everts on wheat at various constant temperatures and relative humidities indicated that the pest thrived best at 35° C. At 40° C; the mortality in the egg stage was more and at 20° C; they did not hatch at all. The pest was observed to prefer raw rice to parboiled rice.

Experiments on the damage caused by *Callosobruchus maculosus* in 'mung' stored in jute bags indicated that mung stored in bags made of B-Twill (Sacking) or plain weave (Hessian) was not infested.

Examination of sixty-six samples of vegetable seeds revealed 83% infestation by insects and rodents.

Observations on the susceptibility of sorghum varieties to the attack of *Chilo zonellus* indicated that selections like 'Adhroo' and 'Satpani' withstand the infestation much better than the rest of the varieties.

Studies on the qualitative and quantitative requirements of *Tribolium castaneum* showed that inositol, which is of little or no value to most insects, was required by *Tribolium castaneum*.

Experiments on the effectiveness of malathion, pyrethrins and pyrethrins $\pm$ piperonyl butoxide, when impregnated on jute bags against *Tribolium castaneum*, *Rhizopertha dominica* and *Trogoderma granarium* showed that malathion and pyrethrins even up to 300 mg./sq. ft. were ineffective, while pyrethrins plus piperonyl butoxide at the same dosage caused about 54.6% kill of the *Tribolium* adults.

Tightly woven Hessian type jute bags were observed to be better than B-Twill sacking type against penetration of stored grain pests and contamination of grains with insecticides from surface treatment of bags.

Experiments of quantitative requirements of vitamins for the growth and development of *Trogoderma granarium* larvae exhibited that the growth was normal in the absence of thiamin.

Plant Parasitic Nematodes :

Surveys indicated that the root-knot nematode infestation ranged from 2.8% to 82.5% on different crops. Shoot length, root length and leaf or leaflet area in bhindi, tomato and papaya plants were reduced to almost half the size. An application of 0.2% diazinon near the root zone of infested tomato plants materially reduced the root-lesion nematode population.

Mycology and Plant Pathology

WHEAT AND BARLEY

Rusts.—More than 500 samples of different rusts of wheat and barley were analysed and two new races (a new biotype of race 34 and race 16 of brown rust) have been picked up. The total number of rust races in the Collection is 17 of black rust, 14 of brown rust, 10 of yellow rust and 2 of barley leaf rust.

During survey of Simla Hills, a type ofaecidia occurring on *Berberis lycium* proved to belong to *Puccinia brachypodii* and did not infect the cereals. Teleutospores of black rust from the summer wheat crop collected from Muktinath (Nepal) at an altitude of 11,200 ft. proved to be viable and infected the seedlings of a local Nepalese species of *Berberis* in the laboratory. Over-summering of all the three rusts was observed at different altitudes in the hills.

In the varietal resistance tests, wheat variety N.P. 842 was found to be resistant to all the prevalent races of black rust, H 45-4-14-239-2-pl.4, E.4363 and H 16-23 resistant to brown rust and H.P. 286(A), HD57-197, E. 4340, E.4360, E.4443, E.4444 and E.4446 resistant to yellow rust. In tests with mixture of races, 23 varieties of wheat proved to be resistant to black rust, 10 to brown rust and 35 to yellow rust. Similarly, six barley varieties were found to be resistant to all the races of yellow rust.

Loose Smut and Bunt.—In the varietal resistance tests, wheat varieties E. 2690, E.3097, E.3158, E.3320, N.P. 718, N.P. 797, N.P. 798 and N.P. 799 have consistently remained free from Loose Smut infection for the last three years; and 12 wheat varieties have reacted as resistant to Hill Bunt. In physiologic race studies, 12 races of *Tilletia caries* and 13 races of *T. foetida* have so far been recognised. *T. foetida* is the commonly occurring Bunt species in India.

In the varietal resistance experiments against Karnal bunt (*Neovossia indica*), out of the 99 wheat varieties under test at Karnal, only 14 showed infection while 85 remained bunt-free. The corresponding figures for a similar experiment at Delhi were 140, 21 and 119 and for Kangra 44, 12 and 32.

Linseed Rust.—In connection with the physiologic races of linseed rust studies, 136 samples from different localities and linseed varieties were analysed which yielded four races already known to occur in India and, in addition, a new race more virulent than these four. In the rust resistance tests, out of the 46 varieties tested, only one (Bolley Golden) proved to be resistant to all the races in seedling stage. The aecidial stage of this rust was again found to occur in nature at several places in Kangra Hills.

SUGARCANE

Red Rot and Smut.—In the studies on the variation of the causal organism of the Red Rot of Sugarcane, some important findings and indications of fundamental aspects have been obtained e.g., the role of PABA (Para-aminobenzoic-acid) in pathogenicity;

indications of heterokaryosis resulting in heterokaryons more virulent than either parent; increase of virulence of the pathogen by successive passage through resistant cane varieties; the development of the perfect stage of the Red Rot fungus on hosts other than sugarcane leaves indicating thereby the possibility of the change of the Red Rot organism on passing through such widely different host tissues.

In the varietal resistance tests against Red Rot, of the 182 cane varieties tested, 7 (Co. 371, Co. 1190, Co. 1202, Co. 1223, Co. 1320, B.O. 10 and B.O. 28) proved to be resistant. Similarly, of the 186 cane varieties tested, 48 reacted as resistant to Smut.

Rust.—Studies on the Sugarcane Rust have shown that the disease has spread to quite a few new localities effecting about 50 cane varieties of which 30 were hitherto not reported to be affected with Rust. Indications have also been obtained as to the existence of physiologic forms of the Rust. Regarding collateral host studies, *Erianthus fulvus* rust has been found to infect sugarcane.

MAIZE

'Kans' grass (*Saccharum spontaneum*) has been established to be a collateral host of the Downy Mildew of Maize, with systemic type of infection indicating thereby the mode of perpetuation of the disease. *Oxalis corniculata*, the alternate host of the maize rust, has been found to be naturally infected near maize fields in Nepal Hills during April.

Further studies on *Cercospora* leaf spot of grape-vine have revealed the presence of pectinase inhibitor in the grape-vine leaves. The inhibitor from two New Zealand varieties, Golden Chasselas and Concord, which are immune to this disease was most effective while that from highly susceptible variety, Anab-e-Shahi, was least effective. The inhibitor is non-specific, stable to boiling but is destroyed when autoclaved at 15 lb. pressure for 15 minutes.

FUNGICIDES

In a comparative field fungicidal trial against black rust of wheat, four sprays of Parzate liquid plus zinc sulphate gave effective control, greatly reducing the rust incidence in the sprayed plots and significantly increasing the yield.

The pathogenicity of *Heterodera major*, the causal organism of the "Molya" disease of wheat and barley occurring in Rajasthan, was established on these hosts. No stimulant was required for the cysts to hatch provided suitable temperature and requisite amount of moisture were available.

Virus Diseases.—Chlorosis of *jowar* and mosaic diseases of mulberry, fig and onions were established to be of virus origin. Chlorosis of *jowar* was transmitted by the leaf-hopper, *Peregrinus maidis*. Mango malformation was reproduced in mango seedlings with the eriophyid mites collected from apparently healthy mango shoots indicating thereby the true nature of the disease. An eriophyid mite has been found to be the vector of the sterility disease of pigeonpea. The antigenicity of bottle-gourd mosaic virus (*Cucumis virus 2C*) was established and the virus gave a flocculent precipitate with its antiserum. *Carica cauliflora* was found to be immune to papaya mosaic virus and may prove useful as a source of resistance in evolving mosaic-resistant papaya varieties.

Two viruses isolated from mosaic affected plants of vegetable marrow were studied and identified as *Cucumis viruses 1* and *3*. The former was transmitted through 4 aphid species (*Myzus persicae*, *Aphis gossypii*, *A. craccivora*, *A. evonymi*) and the Red Pumpkin Beetle (*Rhipidopalpa foveicollis*); and the latter through *M. persicae* and the plant bug, *Engyptatus tenuis*.

Studies on the inhibition of Sannhemp mosaic virus have shown the presence of inhibitors in roots, leaves and green fruits of *Capsicum annuum* and roots and leaves of *Beta vulgaris* and *Raphanus sativus*. The inhibitor from *C. annuum* was found to be thermostable, resistant to ageing *in vitro* for 72 hours and desiccation for 1 week and did not pass through a cellophane membrane. Of the various fungi and bacteria tried, culture filtrates of *Trichothecium rossum*, *Rhizoctonia solani*, *Serratia marscens*, *Pseudomonas solanacearum* and *Aerobacter aerogenus* were found to inhibit sannhemp mosaic virus. Inhibition of the virus was also obtained with Cytovirin, thiouracil, urea, milk and whey.

Physiology of Fungi.—Further studies on bulbiformin, an antibiotic from *Bacillus subtilis*, showed that its production on the seed-coat and rhizosphere can be considerably enhanced if oil-cakes and molasses are used as base for seed bacterisation.

Effect of Atomic Radiation on Microorganisms.—Pathogenicity experiments of the biochemical mutants of *C. falcatum* induced through beta-radiation showed that the loss in pathogenicity on sugarcane can significantly be restored by incorporating para-aminobenzoic acid into the host system through roots.

Assessment of Losses due to Plant Diseases.—Loss in yield (kernel) due to groundnut mosaic was observed to be 30.4, 64.4, 82.3, and 92.2 per cent. at 25%, 50%, 75% and 100% disease intensity levels. In the case of linseed rust, it was observed that the loss in yield of N.P. 12 was 93.7, 54.8 and 16.5 per cent. when infected at 1½, 2½ and 3½ months growth stage, respectively, while in the case of N.P. 21, which is more susceptible than N.P. 12, the loss was 99.3, 92.4 and 70.4 per cent. when inoculated at the same stages of growth. The data on maize blight revealed that the loss in yield of grain ranged from 27.6 to 90.7 per cent. depending on the intensity of infection. Further, it was found that the loss in yield was almost proportional to the disease intensity. Experiments on angular leaf spot of cotton indicated that, under Delhi conditions, there was no loss in yield due to the leaf spot alone, however severe the spotting may be. In the case of potato mild mosaic, masking which occurs at higher temperatures was found to help the plant in making up the loss to some extent. It was observed that plants with 2-4 weeks of masking gave 8-12 per cent. higher yields over those that continued to show mosaic symptoms.

Soil Science & Agricultural Chemistry

A. AGRICULTURAL CHEMISTRY

Cowdung Gas Plant.—The gas obtained from the cowdung gas plant has been found to be suitable for operating petrol engines and utilizing the power for generating electricity, pumping water etc. About 50 C.ft. of gas is consumed in an hour for operating a 5 H.P. engine pumping water through a 2" discharge pipe.

B. ORGANIC CHEMISTRY

Pyrethrins from the pyrethrum flowers are perhaps the costliest and the most useful of the insecticides. Through the use of synergists, it is possible to reduce the quantity of pyrethrins required. It has been observed that 2-n-amyl-3-piper-onyl acrolein exhibited high degree of synergism, when tested against adults of *Tribolium castanum*; 0.02% pyrethrins alone caused only 60.9% kill of the insects, while 0.01% of pyrethrins in conjunction with 0.25% of the compound gave 98% mortality.

Extractives from neemseed cake (bitters) practically free from the fatty oils and acids have been obtained in 10-12% yield. The product has shown interesting properties as insect repellent and insecticides.

C. PHYSICAL CHEMISTRY

Application of bentonite.—Application of bentonite at the dose of 6 tons per acre to Delhi soil has shown an increase of 38% in the yield of wheat.

D. PHYSICS

Analysis of the ground-water data available at the I.A.R.I. from 1940 onwards revealed that about 42-51% of the total rainfall received and 9-11% of the total irrigation applied reach the ground-water level, if surface drainage is neglected. The results clearly indicated the importance of taking effective measures regarding proper surface drainage at the I.A.R.I. farm area to decrease the ground-water level.

X-ray and electron microscopic studies on a number of clay minerals obtained from Hyderabad, Mysore and Himachal Pradesh indicated definite presence of nontronite, a clay mineral which could not be distinguished separately from montmorillonite in the earlier studies.

Using the spectrophotometric method standardised in this laboratory, capsaicin content of chillies was estimated in 12 promising N.P. varieties. The capsaicin content ranged from 0.2 to 1.2% of the dried material.

E. SOIL SURVEY & SOIL PHYSICS

Genesis of clay minerals in the soil clays was observed to have a definite relation to primary minerals in the silt and fine sand fractions of contiguous red and black soils from Coimbatore. Clay fractions isolated from both the soils were dominantly montmorillonitic with traces of illite and kaolinite.

F. BIOCHEMISTRY

The protein efficiency ratio of twelve important wheats was found to vary from 1.63 to 1.93.

G. RADIOTRACER INVESTIGATIONS

Investigations using radioactive phosphorus showed that *dhaincha* had a great capacity to utilize the phosphorus present in the subsoil depths. These studies suggest that it will be possible to select a suitable crop with the highest efficiency of transfer of phosphorus and possibly other nutrients from subsoils to the surface soil.

Studies on the physico-chemical changes accompanying organic matter addition and flooding and the availability and utilization of phosphorus by rice on two different soils have clearly brought out that rice plant maintains the soil pH in a definite range during its growing period and the pH change has little influence on its oxidation potential. Concentration of ferrous iron, ammonia and exchangeable manganese increases and these lead to higher uptake of phosphorus.

Effect of degree of soil saturation in respect of cations and anions on utilization of phosphorus by crop has shown that increase in the degree of phosphate saturation increases total uptake of phosphorus in all soils, but the critical level for each cation system and the soil type for optimum uptake of phosphorus, is different.

In placement experiments with linseed it has been found that placement of phosphatic fertilizer 2½" sideways and 1-3" below seem to be superior with respect to fertilizer uptake to all other modes of phosphate fertilizer application.

H. SOIL TESTING LABORATORY

Soil Test crop-response correlation for potassium on paddy using a number of different soils and various procedures for determination of available potassium showed that Hunter and Pratt's method using 6 N H_2SO_4 is the best ($r = -0.6766$). In the soils having illite as the dominant clay mineral Barbier and Morgan's method using ammonium acetate gave promising results. In acidic soils acetic acid extraction and percentage potassium saturation were found to give a better picture of potassium supplying power of soils.

Microbiology

1. SOIL MICROBIOLOGY

Some salt tolerant strains of *Rhizobium* of pea (*Pisum sativum*), methi (*Trigonella foenum-graecum*), urid (*Phaseolus mungo*) and beans (*Dolichos lablab*) having high nitrogen fixing power were obtained. Seed inoculation with phosphobactrin, a bacterial fertilizer from U.S.S.R. increased crop yields significantly in 11 out of 17 field trials with different crops under different soil and climatic conditions.

The Rhizosphere of wheat supported a higher total bacterial count, *Azotobacter* population and amino acid requiring bacteria, vitamin B₁₂ synthesisers. The rhizobium of berseem and soybean synthesised more vitamin B₁₂ than those of cowpea or peas or the non-symbiotic nitrogen fixed *Azotobacter*. *Azotobacter* from rhizosphere of wheat fixed more nitrogen than that from the control.

2. ALGAE

Nostoc and *Chlorella vulgaris* were able to utilise the extracellular substances given off by the former. Experiments are in progress to study the effect of algal inoculation in increasing crop yields.

All India Soil & Land use Survey.—The All India Soil and Land Use Survey Organisation with four Soil Correlation Centres, at Delhi, Nagpur, Bangalore and Calcutta representing the four major soil groups of the country carried out standard detailed soil survey in the different catchment areas of the dams on Machkund, Hirakud, Bhakra-Nangal and Chambal for providing basic soil information for soil conservation purposes and in other areas at the instance of State Governments where land development for irrigation, agriculture, pasture, rehabilitation, soil conservation etc., had been projected under priority basis. Reconnaissance soil survey was also carried out in the States of Madras, Mysore, Kerala, Andhra Pradesh, Maharashtra, Punjab, Orissa, West Bengal and Tripura under the original research programme of soil correlation. The morphological study of the soil profiles, an important aspect of field research and laboratory examination of the profile soil samples, helped in tentatively arriving at a large number of classificational units which are being correlated for establishment of series and types. The normal research and study in soil correlation and interpretation involved classification and nomenclature of soils in the catchment and non-catchment areas and determination of the potentialities and limitations of the classificational units in effective exploitation.

During the year under report a total area of 27.60 lakh acres, as against a target of 25 lakh acres, was surveyed of which 8.03 lakh acres were covered by detailed survey and 3.49 lakh acres by detailed-reconnaissance survey and 16.08 lakh acres by reconnaissance survey.

The main Cartographic Laboratory attached to the Headquarter continued the work on basic soil regions. The topography has been computed on the basis of the following slope ranges, namely 1.2, 2.4, 3.6, 5, 5.2, 6.4, 7.6, 8.8 and 9% for a large number of districts.

Map compilation, fair mapping, photography, plate graining sensitizing etc., were continued.

In all 30 soil survey and land use reports together with soil and land capability maps covering a total area of 23.35 lakh acres were drawn up during the period and sent to the concerned states for comments and execution purposes. Besides soil classification and present land use these reports deal with land capability classes in formulating programmes of conservation agriculture, forestry, recreation etc.

The Soil Survey Manual published under the auspices of the organisation is being further amplified by inclusion of illustrations of textural graphs, structure, and profiles of established series.

3. THE POST-GRADUATE SCHOOL

The Post-Graduate School of the Institute continued to make steady progress towards its objective of developing a high-quality programme of post-graduate instruction in agriculture and its cognate disciplines. The fourth academic session of the School commenced on the 6th October, 1961.

As in the past, there was a keen competition for admission to the School; 446 applications were received for the M.Sc. course and 257 for the Ph.D. After a careful screening of the applications by the Post Graduate Council, and on the basis of performance at the personal interviews before the Council, 94 candidates were selected for admission to the M.Sc. and 68 to the Ph.D. course. Five students were admitted, for the first time, to the newly-opened M.Sc. course in Agricultural Economics. Among the foreign students admitted to the School this year, there were 4 from Nepal, 2 from Thailand, and one each from Pakistan and West Indies. The number of students on the roll of the School at the end of the year 1961 was 402.

Besides the Council of Scientific and Industrial Research, the Indian Council of Agricultural Research and the University Grants Commission (through the Ministry of Education), which offer post-graduate scholarships for which the students of this Institute can compete, several other bodies, such as the Rockefeller Foundation, the Ministry of Scientific Research and Cultural Affairs, the Atomic Energy Establishment, the Sir Dorabji Tata Trust, Messers, Sahu Chemical Works have made available fellowships and scholarships specifically for the students at this Institute. The Rockefeller Foundation offered 10 Assistantships during 1961, in addition to a similar number offered last year, for the promotion of research for the improvement of cereals. The Foundation was also gracious enough to increase the value of the Assistantship from Rs. 150 to Rs. 200 per month in the case of the M.Sc. students and from Rs. 200 to Rs. 250 per month for the Ph.D. students. In addition to this, two more new fellowships, were instituted during the year for the use of the Ph.D. students—the one, of the value of Rs. 200 per month has been offered by the Bhagwan Finance Private Ltd., of Calcutta and the other, valued at Rs. 250 per month, by the Fertiliser Association of India.

The magnificent support which the Rockefeller Foundation has given to the Post Graduate School includes the assignment of eminent American scientists as Visiting Professors to the School. During the year, the school had the privilege of receiving Dean Robert W. Hodgson of the University of California in the Division of Horticulture, and Dr. Robert M. Hagan, Chairman, Department of Irrigation, University of California and Dr. Milton Fireman, Soil Specialist (Salinity), University of California, both in the Division of Agronomy, as Visiting Professors.

The work on the construction of the new wing of the I.A.R.I. Library was nearing completion. The appointment of a Librarian, in the Senior Class I scale, to take charge of the library marks one of the steps that are being taken to further organise and thus enhance the usefulness of the library.

11 members were admitted to the Post-Graduate Faculty of the School during the year, bringing the total membership to 113. Two members of the Faculty, one each from the rank of Professors and Assistant Professors were elected to the Post-Graduate Council. Dr. M. S. Swaminathan, Cytogeneticist, from among the Professors and Dr. D. N. Srivastava from among the Assistant Professors. Consequent on his appointment as Head

of the Division of Botany at this Institute on the 1st December, 1961, Dr. M. S. Swaminathan ceased, under the rules, his elected membership of the Council. The sad demise of Prof. K. S. Krishnan, D.Sc. FRS, Director of the National Physical Laboratory on the 14th June, 1961 was a great loss to the Post-Graduate Faculty of the School of which he was an Honorary Member.

The most important event and the most successful function of the year was the holding of the first Convocation of the School since the Institute was granted, in 1958, the status of an University for awarding the post-graduate degrees of M.Sc. and Ph.D. Shri S.K. Patil, Union Minister for Food and Agriculture, delivered the Convocation Address and gave away the degree and diploma certificates. 91 candidates were admitted to the M.Sc. degree and 19 to the Ph.D. degree in person and 36 and 21 to the M.Sc. and Ph.D. degree respectively, *in absentia*. Besides, 132 candidates received the diploma of Associateship of the Institute in person and 104 *in absentia*. The Gurdial Pradhan Medal offered by Dr. S. Pradhan was awarded to Shri M. L. Saini for standing first in entomology among the candidates for the diploma of Associateship of the Institute in the year 1958 and to Sarvashri G. K. Punj and E. S. Oonnithan for obtaining the highest grade point average among the M.Sc. students in entomology during the years 1959 and 1960 respectively.

Short Courses.—As in the previous years, a number of short courses on special topics were also organised during the year, in addition to the regular programmes of post-graduate instruction. They included training in maize breeding and seed production, Soil Survey Techniques, seed testing and short course training facilities in the Divisions of Botany and Chemistry. At the instance of the Indian Council of Agricultural Research, a 2-week refresher course in agronomy was conducted in the Division of Agronomy for the benefit of teachers in the various agricultural colleges and research workers in the Department of Agriculture in the country. 33 candidates attended the course.

4. GENERAL

(a) Meetings, Conferences and Deputations

As in the previous years the Director, Heads of Divisions and senior members of the staff attended meetings sponsored by the different Ministries of the Government of India, the I.C.A.R., the different commodity committees and other bodies.

Dr. Gian Singh of the Division of Agronomy was on deputation to Sweden for training in animal reproduction from 10-3-61 to 25-12-61.

Dr. W.V.B. Sundera Rao was on deputation to U.S.S.R. to acquaint himself with regard to Bacterisation experiments with special reference to Phosphobacterin from 13-10-60 to 26-12-60.

Shri K. Swaminathan continued to be on deputation with the Southern Railway and Shri N. M. Neemagade and G. Ramchandra in U.S.A. for higher studies. At the invitation of International Atomic Energy Agency Dr. N. P. Dutta worked on the Penel on the use of radio-isotopes in soil-plant relations and fertilisation studies in Vienna from 15th to 19th May, 1961.

Dr. K. V. S. Satyanarayana, Soil Correlator, Alluvial Soil Region, Delhi, was on deputation to U.S.A. for training in soil survey under the T.C.M. Programme from 4-7-61 to 6-11-61.

Shri J. C. Bhattacharya, Soil Chemist, Red and Laterite Soil Region I, Calcutta, was on deputation under the Andaman Administration from 2-1-61 to 18-6-61 for exploratory soil survey in the island for rehabilitation.

Dr. M. S. Swaminathan visited Italy and Sweden during June, 1961, to deliver lectures at Rome, Stockholm, Lund, Svalof and Landskrona at the invitation of the Italian Atomic Energy Commission and the University of Stockholm.

Conferences.—Dr. N. R. Dutta Viswas, Soil Survey Officer, attended the eighth meeting of the Working Party on Rice, soil, Water and Fertiliser practices of the International Rice Commission held at Vigyan Bhawan during 11th to 16th December, 1961, as observer and took part in the deliberations.

The Eighth Annual Meeting of the study of Agricultural Statisticians and Soil Conservation Officers and Regional Officers for Fertilizer Demonstration Trial was held at the I.A.R.I. from 21st to 25th August, 1961 under the auspices of the All India Soil and Land Use Survey.

The Annual Field meeting of the Chief Soil Survey Officers, Soil Correlators, Soil Survey Officers was held at Bangalore and Ootacamund during 23rd to 29th October, 1961.

The half-yearly meeting of the Soil Correlators was held during 12th and 17th June, 1961 and the other meeting was held on 26th August, 1961.

(b) Visitors

The Institute is annually visited by a large number of Indian and foreign visitors who include Heads of States and other dignitaries, scientists, parliamentarians, trade and cultural delegations, students from agricultural and other colleges in the country and individual farmers and farmers' organisations.

The important visitors during the year under report included His Highness the Maharaja of Bhutan, Shri G. M. Bakshi Prime Minister of Jammu and Kashmir, Shri N. Kanungo, Commerce Minister, Govt. of India, Dr. Eric William, Prime Minister of Trinidad, His Excellency Dr. M. I. Okpara, Premier of Eastern Region of Nigeria, His Excellency U. Nu, Prime Minister of Burma, Farmer President of Brazil, Shri K. I. Dixit of the Department of Industries, Nepal, Mr. Kelly, Member of the Australian Parliament, Malaya Parliamentary Delegation, Shri D. I. Glue, Grassland Expert, Nigeria, Nigerian Economics Delegation, Dr. O.D. Karnnaocho, Counsellor for Agricultural Affairs, U.S.S.R. Embassy, Shri Habibur Rahman, Minister of Education, East Pakistan, Russian Scientists of Trade Representation of the U.S.S.R., Lieut. Gen. Bahadur Singh, Commandant Defence College, National Assembly Delegation from Bhutan, Bulgarian Parliamentary Delegation and several members of the Parliament and Scientists.

(c) Library

Total number of publications received in the I.A.R.I. Library both by way of exchange and purchase was 4,478. Eighty six new periodicals were added to the Library during the year. Publications numbering 12,596 were issued out on loan of which 9,014 publications were sent out to the scientific workers in the States and Universities. The Reading Room was used by 22,325 visitors and 88,017 publications were consulted. In addition, 3,084 items have been indexed and catalogued. Twelve thousand and thirty cards have been typed and a large number of enquiries were attended to concerning publications on specific subjects.

(d) Collections and Herbarium

The foreign plant introduction and indigenous collections made by the Division of Plant Introduction and Exploration numbered 3,299 samples of seeds and planting material imported from foreign countries. An expedition to central Nepal was organised for the collection of plants and planting material, fungi and insect specimens. The members of the expedition surveyed the area between Butwal and Pokhara and between Pokhara

and Muktinath covering an altitude range of 1,200 to 12,000 ft. above the sea level. Four thousand mycological specimens were added to the Herbarium (Herbarium Cryptogamae Indiae Orientalis) bringing the total number of accessions to 27,500. Catalogues in respect of world literature on the taxonomy of fungi and the list of specimens available in the Herbarium are under preparation. The total number of fungal and bacterial cultures in the Indian Type Culture Collection now is 1,117. In addition, 61 cultures of rusts and 55 of plant viruses were being maintained. A large number of cultures were supplied to scientific workers and institutes as also to commercial concerns in the country and abroad, at their request.

(e) Research Schemes

Work on the following research schemes, financed by the Ministry of Food & Agriculture, by the Indian Council of Agricultural Research and by the different Commodity Committees, was in progress in the different Divisions of the Institute during the year under report :—

Title of the Scheme	Sponsored by
<i>Division of Agronomy</i>	
(1) Scheme on Investigation with radio-active Isotope on Cotton Technique.	Indian Central Cotton Committee.
(2) Agronomic Scheme of Pasture Land Improvement . . .	Indian Council of Agricultural Research.
(3) Scheme on Model Agronomic and Simple fertilizer trials	Do.
<i>Division of Botany</i>	
(A-i) Coordinated Maize Breeding Scheme	Indian Council of Agricultural Research.
(ii) Coordinated Scheme for Research on Micronutrients with special reference to Citrus Die-back.	Do.
(iii) Scheme for Cytogenetical and Physiological Studies in relation to Floriculture.	Do.
(iv) Scheme for Cytological, Anatomical and Embryological studies on wheat, Maize, <i>Phaseolus Cajanus</i> , Oilseeds and Cucurbits—I.A.R.I.	Do.
(v) Scheme for the study of Genetic Variability in Algae from the view point of their use in Agriculture.	Do.
(vi) Scheme for the Improvement of the Essential-oil Yielding Plants.	Do.
(B-vii) Establishment of Plant Introduction and Exploration Organisation.	Second Five Year Plan.
(viii) Coordinated Wheat Rust Control Scheme	Do.
(ix) Scheme for the Control of Bunt in Wheat	Do.
(x) Scheme for Studies on the Milling, Baking and Chapati-making qualities of Indian wheats.	Do.
(xi) Scheme for use of Radio-active Isotopes in Cytogenetic Studies.	Do.
(xii) Establishment of a Unit for Embryo Culture work . . .	Do.
(xiii) Scheme for setting up a Seed Testing Station	Do.
(xiv) Scheme for the Establishment of a Fundamental Plant Genetical Research Laboratory.	Do.
(xv) Scheme for setting up of a Cobalt 60 Field Radiation Unit .	Do.
(xvi) Expansion of Botanical Sub-station Pusa	Do.

Title of the Scheme

Sponsored by

Division of Entomology

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|---|---|
| (1) Scheme for exploration of toxicity hazards in the use of modern insecticides against cattle and human beings. | Indian Council of Agricultural Research |
| (2) Scheme for nutritional and biological studies on insects of Agricultural importance. | Do |
| (3) Scheme for Research on Insect Physiology | Government. |
| (4) Scheme for Unit for Storage pest Ecology | Do. |
| (5) Scheme for Unit for Biological Testing and Certification of Insects. | Do. |
| (6) Radioactive Isotopes Scheme | Do. |
| (7) Scheme for Survey of Beneficial Parasites of Pests of Agricultural Crops in Indian Union. | Do. |
| (8) Scheme for Research on Indian Honey Bee at Pusa | Do. |
| (9) Unit for Locust Toxicology Scheme | Do. |
| (10) Seed Testing Scheme | Do. |
| (11) Plant Introduction Scheme | Do. |

Division of Soil Science & Agricultural Chemistry

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|---|--|
| (1) Radio Tracer Investigation | Second Five Year Plan. |
| (2) Unit of Physics | Do. |
| (3) Staff for the working of Electron Microscope | Do. |
| (4) Additional Staff for Gas House | Do. |
| (5) Addition to Gas House | Do. |
| (6) Expanded Soil Test Scheme O.A.4 I & II Suppl. | Do. |
| (7) Foliar Application of Nutrient to the Crops | Indian Council of Agricultural Research. |
| (8) Scheme for Examining of Behaviour of certain additional chemical fertilizers under storage conditions. | Do. |
| (9) Scheme for Exploration of Toxicity Hazard in the use of modern insecticides against the cattle and human being (under Hd. B.) Chemical portion. | Do. |
| (10) Improvement of Essential oil yielding plant under (Hd. B.) Chemical portion. | Do. |
| (11) Investigation on Phosphorus fertilization of cotton by Radio Tracer technique (under Hd. A.) Chemical Portion. | Do. |

Division of Mycology & Plant Pathology

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|---|-------------------------|
| (1) Coordinated Wheat Rust Control Scheme (Mycological Portion) Permanent. | Government. |
| (2) Plant Introduction & Exploration Organisation (Mycological Portion) Permanent. | Do. |
| (3) Coordinated Plant Virus Diseases Scheme. | Second Five Year Plan.* |
| (4) Scheme for the Use of Atomic Energy in Plant Pathological Research. | Do. |
| (5) Scheme for the setting up of Seed Testing Station (Mycological Portion) at Delhi. | Do. |
| (6) Scheme for the study of Bacterial Plant Pathogens | Do. |
| (7) Scheme for Bunt Control (Mycological Portion) | Do. |
| (8) Scheme for Testing of Efficacy of Fungicides | Do. |
| (9) Scheme for the Appraisal of losses due to Plant Diseases | Do. |

Title of the Scheme	Sponsored by
(10) Section of Nematology from 15-10-61	Third Five Year Plan.
(11) Section for the Improvement of Essential Oil Yielding Plant at IARI (Myc. Portion).	Do.
(12) Expansion of Seed Testing Laboratory at I.A.R.I. (Mycological Portion).	Do.
(13) Linseed Rust Scheme	Indian Central Oilseeds Committee.
(14) Scheme for Research on Virus Diseases of Oilseed crops terminated from 26-4-61.	Do.
(15) Scheme for Research on Diseases of Sugarcane terminated from 30-9-61 (A.N.).	Indian Central Sugarcane Committee.
(16) Scheme for the Study of factors responsible for change of Red Rot fungus Flora and allied aspects.	Do.
(17) All India Coordinated Scheme for Research on the investigation & control of Rust Diseases of Sugarcane.	Do.
(18) Coordinated Plant Virus Research Scheme, Eastern Zone, Kalimpong.	Indian Council of Agricultural Research.
(19) Scheme for the Research on Fungicides	Do.

(f) Supply of Pedigree seeds

As in the previous years the demand for seeds of improved varieties of field and vegetable crops evolved at the Institute especially for the seed of N.P. (New Pusa) varieties of wheat was quite heavy. As only a part of the experimental farm area attached to the Institute and its sub-stations could be devoted to pure seed production, the supply of seed fell short of demand. For instance in the case of wheat only 61885 kgs. of seed could be supplied as against a demand of 267230 kgs.

The following quantities of pedigree seed of N.P. varieties of different crops were supplied by the Institute:—

Crop	Quantity (Kilograms)
Barley	1249'599
Maize	4514.916
Paddy	5170.000
Gram	249.061
Oats	878'464
Moong	267.066
Cow Pea	683'000
Bajra	17.500
Jute	102.527
Linseed	63.662
Lentil	49.130
TOTAL	13245.525

(g) Advisory

Besides the advisory committees of the Ministry of Food & Agriculture and of the I.C.A.R. including the Commodity Committees, the Director, Heads of Divisions and the other senior staff of the Institute served on a number of other expert committees of various scientific organisations in India. The Central Silk Board, Ministry of Commerce and Industry has gratefully acknowledged the assistance rendered to the Board by the Director and other Scientists of the Institute who served on the different committees of the Silk Board during the year under report.

In addition to the normal activity of research and post-graduate training, numerous enquiries are received by the Divisions of the Institute seeking advice on various problems *i.e.* cultivation practices, application of fertilisers, manure and chemical weedicides, supply of pedigree seeds and advice on the cultivation of these and other crops, analysis of soil and water for irrigation, identification of plants as well as insects and fungal and bacterial specimens as also control of plant diseases and pests etc.

(h) Land and Buildings

No land was acquired during the year. The following buildings were completed :

1. Laboratory for Fundamental Plant & Genetical Research.
2. Insectary Building.
3. Extension to Mycology Division.
4. Entrance Gate and Guard Rooms.
5. Assembly Hall.

The construction of Cereal Research Laboratory, building for the Horticultural Division, Quarantine House, Additional Wing to the Library, Green House under Plant Tissue Test and Fertilisation Investigation Scheme, sinking of tubewells at the B.S.S. Pusa (Bihar) buildings for the Agricultural Sub-stations at Karnal, were in progress.

Work of air-conditioning of the Temperature and Humidity Control Rooms in the Botany Division was given to the contractor by the C.P.W.D. and tenders for the following works were invited :

- (a) Dispensary Building.
- (b) Club and Social Recreation Centre.
- (c) Toxicological and Physiological Laboratory.
- (d) Pot Culture House for Soil Fertility Scheme in the Chemistry Division.
- (e) Glass House for the Wheat Breeding Sub-Station at Indore.
- (f) Seed Godown for Central Wheat Rust Control Scheme of Botany Division.

Expenditure sanction for the construction of the buildings of the two new Divisions of Agricultural Extension and Agricultural Economics was received from the Government and the C.P.W.D. were requested to take immediate steps in respect of construction.

(i) Accounts

The total expenditure of the Institute and its sub-stations during the year 1960-61 amounted to Rs. 71,36,632 as under :—

	Rs.
1. Office of the Director including Post Graduate School, Estate Office, Library and Hostel	10,92,796
2. Section of Statistics	28,053
3. Division of Chemistry and all India Soil Survey	22,57,348

	Rs.
4. Division of Mycology and Plant Pathology	3,87,290
5. Division of Entomology	3,49,607
6. Division of Botany including Bhowali Sub-station	12,15,895
7. Division of Agronomy	6,79,843
8. Division of Agricultural Economics	25,047
9. Division of Agricultural Engineering	2,96,855
10. Botanical Sub-station, Pusa	86,040
11. Agricultural Research Sub-station, Karnal and Central Vegetable Breeding Sub-station, Katrain	2,22,796
12. Research Schemes	5,15,062
GRAND TOTAL	<u>71,36,632</u>

REPORTS OF THE HEADS OF DIVISIONS

DIVISION OF AGRONOMY

(Dr. O. P. Gautam)

I. WEATHER AND CROPS

The weather data for the period under report are given in table below :

Mean Meteorological observations (1961)

Name of the month	Temperature in °C				Rainfall in mm.		Mean relative humidity at 7 AM	Mean wind velocity in Km per hour	Mean hours of bright sunshine	Mean evaporation from U.S.A. standard evaporimeter in mm.
	Mean max.	Departure from normal	Mean min.	Departure from normal	Total during the month	Departure from normal				
January	20.4	+0.4	6.5	+0.2	28.0	+2.4	86.9	2.9	7.7	2.1
February	20.1	-3.7	7.6	0.0	46.4	+35.6	81.5	6.8	8.1	3.5
March	29.9	+0.3	12.2	-1.0	0.0	-25.8	66.2	5.6	9.0	5.4
April	35.8	-0.2	17.6	-0.8	5.0	-2.1	44.6	7.0	10.0	9.3
May	39.1	-0.9	23.3	-0.7	22.0	+14.1	39.7	7.7	10.1	10.9
June	38.7	-1.6	28.2	+0.6	56.2	+25.7	53.1	11.0	8.7	11.3
July	35.2	0.0	23.7	-3.0	184.4	-35.3	75.1	8.7	7.9	7.4
August	31.6	-1.3	25.5	-0.2	567.2	+394.3	88.5	4.4	4.5	4.0
September	33.2	-0.3	25.1	+1.1	113.3	-2.8	82.6	4.6	8.2	5.4
October	31.1	-0.8	17.5	-0.2	59.7	-10.8	78.6	4.2	9.3	4.5
November	25.3	-2.5	10.0	+0.2	0.2	-3.2	81.8	2.9	9.1	3.0
December	19.4	-2.9	3.9	-2.9	10.6	+8.5	86.3	3.1	7.7	2.1

The total rainfall received from January to December, 1961 was 1093.0 mm which was 400.6 mm. above normal. Unusually heavy rains received in the month of August resulted in water logging over most of the farm area, affecting the growth and yields of the *kharif* crops. The germination of *rabi* crops was normal particularly because of ample conserved moisture in the soil.

The average yields of principal crops are given below :

Crop	Area (Hectare)	Yield per hectare (Quintal) 1961	Yield per hectare (Quintal) 1960
1. Wheat	25.65	17.64	17.72
2. Oats	19.83	17.93	15.31
3. Peas	4.95	14.14	8.85
4. Berseem	11.88	452.20	334.70
5. Potato	2.52	172.95	129.03
6. Maize	10.47	..	16.51

Yields of oats, peas, berseem and potato were higher during the year under report than those obtained during the preceding year. Maize crop failed on the farm on account of heavy rains.

II. RESEARCH

1. Soil Fertility Section :

(i) Permanent Manurial Experiment at New Delhi was continued and the first cycle of the rotations was completed during the year under report.

(ii) The relative efficiency of three organic manures *viz.* F.Y.M. castor cake (each 67 kg. N per hectare) and *guar* green manure with and without 45 kg. N, 90 kg. P_2O_5 and 45 kg. K_2O singly and in combination was studied in a *Fallow-Wheat-Maize-Wheat* rotation. Manures and fertilisers were applied to wheat after fallow. Although the yield responses due to the three forms of organic manure did not differ significantly, all the organic manures significantly increased the grain yield of wheat (following fallow) over the control. There was a further significant increase in wheat yield when 45 kg. N and 90 kg. P_2O_5 were applied. Addition of K_2O did not have favourable effects on the wheat yield.

(iii) Effect of low doses of phosphate in the form of farmyard—manure, super-phosphate and in certain combinations of the two was studied on the yield of berseem green fodder and berseem seed; and the residual effect was studied on the yield of green fodder of cowpeas in the following *kharif*. The results are given in the table below :

Treatments	Yield of Berseem quintal/hectare		Yield of cowpeas quintal/ha.
	Green fodder	Seed	Green fodder
A. F.Y.M. at 18 kg. P_2O_5 /ha	119.9	1.93	56.7
B. F.Y.M. at 36 kg. P_2O_5 /ha	207.5	4.57	66.1
C. F.Y.M. at 72 kg. P_2O_5 /ha	325.2	5.86	89.5
D. Super at 18 kg. P_2O_5 /ha	213.4	4.05	66.1
E. Super at 36 kg. P_2O_5 /ha	342.9	5.64	71.5
F. Super at 72 kg. P_2O_5 /ha	459.9	6.15	85.7
G. Super at 9 kg. P_2O_5 /ha + F.Y.M. 9 kg. P_2O_5 /ha.	151.3	2.64	57.5
H. Super at 9 kg. P_2O_5 /ha + F.Y.M. 27 kg. P_2O_5 /ha.	208.3	4.11	76.1
I. Super at 9 kg. P_2O_5 /ha. + F.Y.M. 63 kg. P_2O_5 /ha.	415.5	5.64	70.4
J. F.Y.M. at 9 kg. P_2O_5 /ha. + Super 27 kg. P_2O_5 /ha.	275.9	5.40	75.1
K. F.Y.M. at 9 kg. P_2O_5 /ha. + Super 63 kg. P_2O_5 /ha.	411.2	6.26	91.0
L. No manure	88.4	1.25	58.8
M. Fallow in <i>rabi</i>	..	..	55.4
'F' test	Sig. 1%	Sig. 1%	Sig. 1%
S.E.m.	±26.05	±0.54	±7.72
C.D. (5%)	73.69	1.53	21.84

Increasing doses of phosphate showed increased yields of both berseem fodder and seed. The effects due to 72 kg. P_2O_5 were highly significant over lower doses. The cowpea crop was adversely affected by heavy rains. The residual effects of 72 kg. P_2O_5 was significant as indicated by the increased yield of cowpea green fodder.

(iv) Under rainfed conditions, wheat yields did not show significant after-effects of phosphate manuring of *guar* taken in the preceding *kharif* although there was a definite trend in favour of the residual effect. Direct application of 28 kg. P_2O_5 in addition to

22 kg. nitrogen per hectare increased the yield of wheat significantly (2.0 quin./hectare) over that due to nitrogen alone. The yield of green fodder of *guar* crop in *kharif* 1961 unlike the previous years was not increased due to phosphate fertilisation probably on account of unusually heavy rains in August, 1961.

(v) Three cultures of phosphobacterin, *viz.* Russian., Indian and Czechoslovakian (fosfo-24) used as inoculum for berseem seed did not affect the green fodder yield significantly. However, their interaction with different forms of phosphatic fertiliser was significant. Superphosphate in conjunction with phosphobacterin (Russian culture) produced significantly higher yield than superphosphate alone. Likewise, Fosfo 24 in conjunction with rock phosphate was superior to rock phosphate alone.

(vi) Yields of wheat, potato, berseem, cotton and maize in the Permanent Rotation Experiment did not differ significantly due to rotational effects with the schedule of fertilisation and manuring prescribed in the experiment. However, the indications were that the yield of wheat and potato were higher wherever preceded by fallow. Berseem yields were higher after cotton than after maize. Yield of maize+cowpeas (green fodder) was significantly higher when taken after berseem than after wheat.

(vii) The effect of fertilisers was studied on crop production on two 2.43-hectare holdings with crop rotations (a) *Fallow-Wheat-Jowar-Gram* (b) *Fallow-Barley-Guar-Fallow* and (c) *Fallow-Wheat+Gram-Bajra-Gram+linseed* under rainfed conditions. The cropping scheme and the yield of crops with and without fertiliser use are presented in table below :

Crop	Area (hectare)	Yield in quintal per hectare		
		Holding-1 with ferti- lisers	Holding-2 without fertilisers	Increase in yield due to fer- tiliser use
<i>Kharif</i>				
Bajra	0.4	5.53	3.30	2.23
Guar	0.4	3.69	2.17	1.52
Jowar (Green)	0.4	220.43	50.73	169.70
<i>Rabi</i>				
Wheat	0.4	6.92	4.61	2.31
Barley	0.4	15.33	9.78	5.55
Wheat+Gram	0.4	10.00	6.24	3.76
Gram+linseed	0.4	2.15	1.84	0.30
		0.65	0.53	0.11

Application of fertilisers increased the yield of all the crops. The maximum and most remunerative increases in yields were obtained with *jowar* fodder in *kharif* and with barley in *rabi*. Barley yields were about twice as much as those of wheat under identical conditions indicating that barley is a more profitable substitute for wheat under *barani* conditions. These results were consistent with those of the previous years.

(viii) Yield data on *Arhar*, maize and wheat from the Permanent Manurial and Rotation Experiment in progress at Pusa (Bihar) are given below :

Plot No.	Treatment	A series		B series	
		<i>Arhar</i> NP.80 qu./ha.	Maize qu./ha.	Wheat NP.52 qu./ha.	Maize qu./ha.
1	No manure	7.81	9.60	3.25	6.59
2	F.Y.M. : 4484 kg./ha.	9.49	22.88	9.09	19.48
3	F.Y.M. : 8967 kg./ha.	12.00	27.01	11.89	22.44
4	F.Y.M. : 4484 kg. + Rape cake 22 kg./ha.	10.15	25.67	9.28	20.76
5	Rape cake 45 kg./ha.	9.38	23.10	6.40	14.29
6	Amm. Sulph. 45 kg./ha.	8.93	6.25	2.88	3.85
7	Pot. sulphate 56 kg. K ₂ O/ha.	9.26	12.55	4.71	6.47
8	Super 90 kg. P ₂ O ₅ /ha.	15.29	15.68	8.37	9.26
9	PK as in plots 8 & 7	15.29	16.97	8.27	10.04
10	NPK as in plots 6 & 8	12.84	19.31	12.62	14.29
11	NP as in plots 6 & 8	18.64	18.70	11.93	11.61
12	G.M. in cereal rotation	5.76	G.M.	5.49	G.M.
13	No manure	6.25	4.85	2.24	4.35
14	NK as in plots 6 & 7	6.59	6.42	3.48	4.80
15	G.M. + legumes in the rotation	10.21	G.M.	7.04	9.66
16	As in Plot 15, plus 90 kg. P ₂ O ₅ /ha. to G.M. crop	12.05	G.M.	14.08	12.67
17	Cereal rotation	1.96*	3.82	1.51	3.26
18	No manure	5.25	4.60	2.04	3.86

*These yields are of barley N.P. 21

Organic manures were applied to the *kharif* crops, while the fertilisers were applied half to *kharif* crop and half to the *rabi* crop. *Arhar* showed a remarkable response to phosphate alone or in combination with other fertilisers. Highest yield of wheat was obtained with green manuring fertilised with phosphate (Plot 16) followed by NPK and NP treatments. Maize responded best to farmyard manure at 8967 kg./ha.

(ix) The yields of Oats and maize from the New Manurial Experiment, Pusa (Bihar) are given below :

Treatment	Oats N.P. 1 qu./ha.	Maize qu./ha.
A. No manure	11.63	5.80
B. F.Y.M. 8967 kg./hectare	19.94	18.69
C. Rape cake 45 kg. N/hectare	16.71	18.69
D. Amm. Sulphate 45 kg. N/hectare	13.59	8.89
E. Pot. sulphate 56 kg. K ₂ O/hectare	10.31	6.74
F. Super. 90 kg. P ₂ O ₅ /hectare	13.38	7.56
G. PK as in treatments F and E	12.22	5.20
H. NPK as in treatments D, F and E	16.44	10.18
I. NP as in treatments D and F	16.98	12.23
J. NK as in treatments D and E	13.48	8.38
'F' test	Sig. 1%	Sig. 1%
S.E.m.	±0.84	±1.03
C.D. (5%)	2.33	2.91

Organics were applied in *khari*f season and inorganics half in *khari*f and half in *rabi*. Highest yields of oats were obtained due to the residual effects of farmyard manure of 8967 kg. per hectare followed by N P, rape cake (Residual) and N P K treatments. With organic manures, maize also showed significantly higher yields than N P and N P K treatments.

(x) Direct, residual and cumulative effects of phosphate application were studied in a 'fallow-wheat-jowar-berseem' rotation. Data on the fodder are given below :

Treatments		Yield of berseem green fodder (quintal per hectare)
Direct effect	Control	177.39
	{ 22 kg. P ₂ O ₅ /ha.	306.11
	{ 44 kg. P ₂ O ₅ /ha	491.68
First residual	{ 22 kg. P ₂ O ₅ /ha	103.11
	{ 44 kg. P ₂ O ₅ /ha	259.90
Second residual	{ 22 kg. P ₂ O ₅ /ha	55.15
	{ 44 kg. P ₂ O ₅ /ha	117.87
Cumulative effect	{ 11 kg. P ₂ O ₅ /ha	300.76
	{ 22 kg. P ₂ O ₅ /ha	491.68
	{ 44 kg. P ₂ O ₅ /ha	450.27
S.E.m $\pm$		55.33
C.D. at 5% level		169.64

Application of 22 kg. P₂O₅ to each crop in the rotation gave as high a yield of berseem as 44 kg. P₂O₅ applied directly to the berseem crop. There was also a significant residual effect on berseem of the phosphate applied at 44 kg. P₂O₅ to the preceding jowar crop. There were indications of the residual effect of phosphate applied to the wheat crop, but the differences were not significant.

(xi) The relative efficiency of the two types of nitrophosphate *viz.* ODDA and PEC and single superphosphate was compared at 12, 24 and 48 kg. P₂O₅ per hectare on wheat. The three forms of phosphate did not differ significantly from each other as indicated by their effects on wheat yields.

2. Field Crop Section :

(i) In a cereal rotation *wheat-maize* with and without Hubam clover (*Melilotus alba*) grown mixed with wheat, highest total yield per annum (37.59 quintals) was obtained when each of the crops, wheat and maize, was fertilised with 45 kg. N per hectare. The next best treatment which gave 34.10 quintals/hectare was the one in which wheat and Hubam clover were grown mixed, fertilised with 90 kg. P₂O₅ per hectare and the clover was buried as green manure.

(ii) Work on the assessment of fertiliser requirements (NPK) of hybrid maize U.S. 578 was continued. The yield data and protein content of grain under medium and low fertility soil conditions are presented below :

Yield and protein content of Hybrid maize U.S. 578

Treatment	Medium fertility (1960-I)		Low fertility (1960-II)	
	Grain yield qu./ha.	Protein per cent	Grain yield qu./ha.	Protein per cent
A. Levels of N :				
67 kilogram/ha.	17.43	9.897	11.56	10.264
135 kilogram/ha.	23.15	10.272	14.19	10.295
202 kilogram/ha.	20.75	10.532	11.84	10.524
S. Em. $\pm$	0.102	0.33	0.107	
C. D. (5%)	2.31	0.398	0.97	Not sig.
B. Levels of P₂O₅ :				
0 Kilogram/ha.	18.63	10.148	11.56	10.227
45 Kilogram/ha.	20.75	10.240	13.19	10.355
90 Kilogram/ha.	21.95	10.311	12.84	10.503
S. Em. $\pm$	0.76	0.132	0.37	0.107
C. D. (5%)	2.25	Not sig.	1.08	Not sig.
C. Levels of K₂O :				
0 kilogram/ha.	18.91	10.214	11.53	10.273
45 kilogram/ha.	20.57	10.266	12.91	10.310
90 kilogram/ha.	21.86	10.218	13.16	10.501
S. Em. $\pm$	0.79	0.132	0.34	0.107
C. D. (5%)	Not sig.	Not sig.	0.99	Not sig.
D. Extra treatment :				
Nitrogen—0 Kg.				
plus P ₂ O ₅ 90 kg.				
plus K ₂ O 90 kg./ha.	12.17	..	9.27	..

Yield increases were significant for increasing levels of nitrogen and phosphorus at medium fertility level and for nitrogen, phosphorus and potash at low fertility level. The protein content of grain was increased significantly by nitrogen applications at medium fertility level. Under medium fertility conditions fertiliser doses of 135 kg. N+45 kg. P₂O₅ was found to be optimum.

(iii) Response of hybrid maize Texas 26 to different micro-nutrients was studied with and without NPK as a basal dressing. Yields of total dry matter and grain are given in the table below :

Treatments	Yield of total dry matter tons/ha.	Yield of grain kg./ha.
1	2	3
Control (No NPK)	3.775	539.81
Zn+other micronutrients in soil (no NPK)	3.866	458.53
Zn+other micronutrients as spray (no NPK)	2.757	282.83

1	2	3
Zn+other micronutrients as seed soaking (no NPK)	3.218	353.38
NPK (no micronutrients)	6.869	1714.87
NPK+Zn in soil	7.938	2140.47
NPK+Zn as spray	5.976	1498.20
NPK+Zn+other micronutrients in soil	7.430	2257.38
NPK+Zn+other micronutrients as spray	6.566	1380.48
NPK+Zn+other micronutrients as seed soaking	8.260	2232.91
S. Em. $\pm$	0.253	272.09
L.S.D. at 5%	0.500	537.47
L.S.D. at 1%	0.667	..

Zinc application (soil or spray) with or without other micronutrients had a depressing effect on the production of hybrid maize. Significant increase in dry matter yield over the control was obtained when Zn was applied in conjunction with NPK. The increase in grain yield was, however, not significant over that due to NPK alone. Soil application of Zn with other micronutrients *viz.* Cu, Mn, Fe, B and Mo and NPK significantly increased the yield of both dry matter and grain over that due to NPK.

(iv) Work carried out on the transplanting of wheat varieties N.P. 710, N.P. 718, N.P. 823, N.P. 824, N.P. 798 and N.P. 835 showed no differential response in respect of the age of the seedlings (30 or 45 days) and nitrogen doses (34 and 68 kg./ha). Crop transplanted on 2nd December yielded significantly higher than that transplanted on 17th December or 2nd January. A spacing of 25×25 cms. was found to be optimum for transplanting wheat seedlings. Wheat drilled on 18th October, 2nd November and 17th November yielded equally well and only about 35% more than the wheat sown in nurseries on these dates and transplanted later on.

(v) Responses of three linseed varieties (NPRR. 9, 38 & 45) to nitrogen application at three levels (22, 44 and 88 kg. N per hectare) and with three seed rates (5.5, 11 and 22 kg./hectare) were studied under irrigated conditions. The yields of linseed varieties did not differ significantly from each other. A dose of 44 kg. nitrogen per hectare seemed to be optimum for linseed. Seed rate of 22 kg. per hectare gave the highest yields.

Improvements of Pasture Grasses and Legumes.—(i) The effect of three nitrogen levels and three intervals of cutting was studied on three promising perennial grasses. The yield data are presented in the table below :

Effect of Main treatments on the green herbage yield (qu./ha.)

1. Perennial Grasses	2. Nitrogen levels	3. Cutting intervals
Napier . . . 607.32	0 kg./ha. . . 332.94	30 days . . . 370.81
Setaria . . . 470.23	90 kg./ha. . . 505.50	45 days . . . 566.41
Para . . . 455.04	180 kg./ha. . . 692.26	60 days . . . 593.57
S. Em. . . ± 16.21	± 16.21	± 16.21
'F' test . . . Sig.	Sig.	Sig.
C.D. at 1% . . . 73.51	73.51	73.51

Effect of cutting interval and nitrogen levels on the green herbage yield of grass (qu./ha.)

Nitrogen levels (kg./ha.)	Cutting Intervals		
	30 days	45 days	60 days
0	295.74	411.35	427.95
90	423.18	633.46	666.82
180	545.23	886.33	929.06
S. Em.	±28.09		
'F' test	Sig.		
C. D. at 5%	82.38		

Napier grass gave 136 and 150 quintals per hectare more yield than *Setaria* and *Para* grasses respectively. On an average 180 kg. N/hectare gave 360 and 187 quintals per hectare more yield than the control and 90 kg./hectare. With sixty days of interval of cutting treatment, 223 and 27.7 quintals more yield was obtained than with 30 and 45 days respectively. All the differences were significant. The only interaction of nitrogen levels and cutting intervals was significant with higher level of nitrogen and longer interval of cutting the green herbage yield increased progressively.

(ii) *Urochloa mosambicensis* was found to be significantly superior to *Panicum maximum* and *Chloris gayana*, which gave an increased fodder yield of 171.5 and 436 quintals per hectare respectively. On an average 90 kg. N per hectare gave 65.5 and 119 quintals per hectare more yield than 45 kg. N/hectare and control respectively. The green fodder yield of the grasses increased with increasing levels of nitrogen and potash, but the differences were not significant.

(iii) The effect of three levels of nitrogen on green herbage yield of five collections of *Cenchrus ciliaris* was studied. These collections did not differ significantly from each other and the yield varied from 128 to 145.7 quintals per hectare. Nitrogen applications at 45 and 90 kg. increased the yield by 35 and 60.9 quintals per hectare respectively over the control.

(iv) Lucerne under irrigated conditions and velvet bean under rainfed conditions exhibited little response in yield due to phosphate application.

(v) A paddock of two promising grasses *Cenchrus ciliaris* (anjan) and *Urochloa mosambicensis* were established for conducting grazing studies. Out of the 30 grasses and 12 legumes under observation, Pusa Giant Napier, Pusa Giant Anjan, *Cenchrus ciliaris* (A-7382, 5603) *Digitaria decumbens*, *Digitaria pentzali*, *Andropogon gayanus* *Alysicarpus Vaginalis*, *Medicago falcata* were found to be promising.

Radio-tracer Scheme.—(i) Studies with tagged superphosphate on linseed indicated no response in yield due to phosphorus at 34 kg. P_2O_5 per hectare applied by six different methods including mixing the fertiliser in the top soil (5–10 cms.) and placement below or in band to the side of the seed. The yield varied from 21.5 to 22.8 quintals per hectare under different treatments.

(ii) Radio-Isotope investigations on utilisation of phosphate by potatoes was conducted for the third year in succession. The yields of potatoes under different treatments were as under :

Treatments	Yield in quintals/hectare	
Control		136.61
34 kg. P_2O_5 /ha.		174.94
68 kg. P_2O_5 /ha.		188.57
102 kg. P_2O_5 /ha.		187.23
'F' test	Significant at 1%	
S. Em.	± 0.13	
C.D. at 1%	0.55	

Methods of application

Broadcast application	216.98
Double band 2½" to the sides in level with seed	170.64
Double band 2" below seed	152.96
Single band at seed level	173.28
Single band 2" below seed	156.15
Broadcasting in opened furrows followed by splitting back of ridges	160.77
'F' test Significant at 1 per cent	± 0.32
S. Em.	
C. D. at 1%	1.29

68 and 102 kg. of P_2O_5 per hectare application gave significantly higher yield when compared to 34 kg. P_2O_5 per hectare application and control. Contrary to the past results, broadcasting of phosphatic fertiliser was significantly superior as compared to placements. Among placements, single band at seed level was superior to other applications.

(iii) Placement studies with tagged superphosphate on cotton (F. 216) completed the third year of the project. The yields of seed cotton in quintals per hectare under different treatments were as under :

Doses of P_2O_5		Single band placement		Double band placement	
	quintals/hectare		quintals/hectare		quintals/hectare
P_1	13.78	H0	14.14	M0	12.80
P_2	13.71	H1	13.53	M1	14.90
P_3	14.09	H2	13.90	M2	13.87
'F' test	Not sig.		Not sig.		Sig. at 1%
S. Em.	± 0.88		± 0.88		± 0.88
C. D. at 1%	..		..		3.48

Highest yield of seed cotton was obtained under double band placements 7.5 Cms. below the seed. An extra yield of 2.10 quintals of seed cotton per hectare was obtained under this treatment over broadcast application. Interactions of phosphorus levels with methods of placement were significant.

3. Vegetable and Commercial Crops Section :

Data on the yield of cauliflower variety Snowball, as affected by different fertilizers and manurial doses are given below :

Treatments					Yield of cauliflower (qu./ha.)				
<i>Levels of Nitrogen</i>									
0 kg./ha	.	.	.	.	75.58	S. Em.	.	.	± 3.20
67 kg/ha	.	.	.	.	109.60		.	.	
134 kg/ha	.	.	.	.	132.65		C. D. at 5%	.	9.39
<i>Levels of P₂O₅</i>									
0 kg/ha	.	.	.	.	93.78	S. Em.	.	.	3.20
45 kg/ha	.	.	.	.	108.04	C. D. at 5%	.	.	9.39
90 kg/ha	.	.	.	.	115.92				
<i>Levels of K₂O</i>									
0 kg/ha	.	.	.	.	102.51	S. Em.	.	.	± 3.20
45 kg/ha	.	.	.	.	106.73				
90 kg/ha	.	.	.	.	108.52				
<i>Levels of F.Y.M.</i>									
6.2 tons/hac.	.	.	.	.	97.78	S. Em.	.	.	± 3.20
12.4 tons	.	.	.	.	114.06	C. D. at 5%	.	.	4.05

Increases in cauliflower yield due to a basal dressing of farmyard manure at 12.4 tons per hectare was found to be significantly higher than that due to 2.5 tons F.Y.M. per acre. Application of 67 and 134 kg N/hectare increased the yield by 34.02 and 57.06 quintals per hectare respectively over the control. These differences were found to be statistically significant. Application of 45 kg P₂O₅ per hectare gave an extra yield of 14.25 quintals per hectare over the control. Additional yield due to 90 kg P₂O₅ was not however, significant over that due to 45 kg. P₂O₅. Potash application did not affect the yield of cauliflower materially.

(ii) Manurial cum varietal trial on peas, varieties N.P. 29 and Bonneville, was conducted under irrigated conditions. The results are presented below :

Treatments						Yields of peas (qu/ha)				
<i>Levels of Nitrogen</i>										
0 kg/ha	.	.	.	.	.	25.98	S.Em.	.	.	±0.862
11 kg/ha	.	.	.	.	.	25.56				
22 kg/ha	.	.	.	.	.	24.39				
<i>Levels of P₂O₅</i>										
0 kg/ha	.	.	.	.	.	24.66	S. Em.	.	.	±0.862
45 kg/ha	.	.	.	.	.	24.91				
90 kg/ha	.	.	.	.	.	26.35				
<i>Levels of K₂O</i>										
0 kg/ha	.	.	.	.	.	25.24	S. Em.	.	.	±0.706
45 kg/ha	.	.	.	.	.	25.37				
<i>Levels of F.Y.M.</i>										
0 ton/ha	.	.	.	.	.	25.75	S. Em.	.	.	±0.248
5 tons/ha	.	.	.	.	.	24.86	C.D. at 5%	.	.	0.705
<i>Varieties of peas</i>										
N.P. 29	.	.	.	.	.	23.19	S. Em.	.	.	±0.784
Bonneville	.	.	.	.	.	27.44	C.D. at 5%	.	.	2.330

There were no significant differences in yield due to varying levels of nitrogen, phosphorus and potash when superimposed on a basal dressing of farmyard manure. Application of 12.4 tons farmyard manure per hectare gave significantly higher yield of peas than control, (no F.Y.M.).

Under the climatic conditions obtainable at Delhi, Bonneville appears to be more promising than N.P. 29. It gave 4.25 quintals more yield per hectare than N.P. 29 and this difference was found to be statistically significant.

(iii) The experiment to work out the manurial schedule for turnip was continued. The total yield of turnip for three pickings, as influenced by varying levels of N.P.K. and F.Y.M., is given below.

Treatment										Yield of turnips (qu/ha)		
<i>Levels of Nitrogen</i>												
0 Kg/ha	.	.	.	.	.	.	.	.	.	449.48	S. Em.	±13.24
45 kg/ha	.	.	.	.	.	.	.	.	.	476.29	..	..
90 kg/ha	.	.	.	.	.	.	.	.	.	482.60	..	..
<i>Levels of P₂O₅</i>												
0 kg/ha	.	.	.	.	.	.	.	.	.	444.75	S. Em.	±13.24
45 kg/ha	.	.	.	.	.	.	.	.	.	488.91	..	..
90 kg/ha	.	.	.	.	.	.	.	.	.	474.72	..	..
<i>Levels of K₂O</i>												
0 kg/ha	.	.	.	.	.	.	.	.	.	440.00	S. Em.	±13.24
45 kg/ha	.	.	.	.	.	.	.	.	.	490.49	C. D. at 5%	38.80
90 kg/ha	.	.	.	.	.	.	.	.	.	477.87	..	..
<i>Levels of F. Y. M.</i>												
2.5 tons/ha	.	.	.	.	.	.	.	.	.	459.48	S. Em.	±6.15
5 tons/ha	.	.	.	.	.	.	.	.	.	484.19	C. D. at 5%	17.59

Farmyard manure applied as a basal dressing at 5 tons increased the yield of turnips by 24.9 quintals per hectare over that due to 2.5 tons dose. Superimposition of nitrogen and phosphorus (each at 45 and 90 kg. per hectare) over the farmyard manure treatment failed to add to the yield of turnip over F.Y.M. alone. Application of potash at 45 kg. K₂O per hectare however, increased the yield significantly over the control.

(iv) Relative efficiency of various nitrogenous fertilizers and methods of their application was studied on onion. Significant improvement in yield was noted with 67 kg. N per hectare. Higher doses did not add significantly to the onion yield. The fertilizer materials namely ammonium sulphate, ammonium chloride, ammonium nitrate and urea were found equally effective on equivalent nitrogen basis. In another trial, significant increase in yield was obtained due to nitrogen at 84 kg. plus P₂O₅ at 28 kg/ha applied either by placement or broadcast method.

(v) Yield of sugarcane from a Manurial-cum-Varietal trial are given below.

Treatment Varieties					Yield of Sugarcane (qu/ha)	Nitrogen					Yield of sugarcane (qu/ha)
Co. 797	.	.	.	.	737.53	Control	.	.	.	.	877.81
Co. 647	.	.	.	.	840.32	45 kg/ha	.	.	.	.	915.60
Co. 659	.	.	.	.	905.63	90 kg/ha	.	.	.	.	896.58
Co. 1109	.	.	.	.	1062.02	135 kg/ha	.	.	.	.	895.37
Co. 997	.	.	.	.	967.01						
Co. 1104	.	.	.	.	831.44	S. Em.	.	.	.	.	±20.29
S. E.M.	.	.	.	.	±56.15						
C.D. at 5%	.	.	.	.	119.65						

Co. 1109 and Co. 997 significantly out-yielded other varieties including Co. 647 which has been a standard improved variety released to farmers in Delhi State. Nitrogen doses varying from 0 to 135 kg. per hectare showed no differential response over a basal dressing of 24.8 tons farmyard manure per hectare following cotton crop.

4. Weed Control Scheme :

(i) The grain yield data from an experiment involving a comparison of cultural and chemical methods of weed control in wheat are presented below :

Treatment	Grain yield (qu/ha) (Var. NP.718)
2,4-D (4 weeks after sowing at 420.30 gms/ha)	29.0
2, 4-D (6 weeks after sowing at 840.60 gms./ha)	27.4
2, 4-D (4 weeks at 420.3 gms+6 weeks at 840.6 gm/ha)	30.2
MCPB (4 weeks at 1.12 kg/ha)	25.0
MCPB (6 weeks at 1.12 kg/ha)	23.0
2, 4-D at 4 weeks 420.3 gms and MCPB at 6 weeks (1.1209 kg/ha)	27.8
2, 4-D at 6 weeks 840.6 gm and MCPB at 4 weeks (10.1 kg/ha)	26.5
Hoeing at 4 weeks	21.3
Hoeing at 6 weeks	20.7
Hoeing at 4 and 6 weeks	19.4
Hand weeding	28.5
Hand pulling	24.2
Unweeded control	16.6
S. Em.	±1.14
C. D. at 5%	3.27

The grain yield was significantly more under all the herbicidal treatments as compared to the unweeded control. 2, 4-D application, 4 weeks after sowing the wheat crop at 420.3 gm acid equivalent per hectare compared favourably with hand weeding.

(ii) Comparative efficiency of chemical and cultural methods of weed control was studied in sugarcane fields. The yield results were as under :

Treatment	Yield of strip- ped cane (qu/ha) Variety Co. 647
1	2
Unweeded control	279.9
Hoeing (on three occasions by bullocks)	391.0
Crag herbicide, pre-emergence 5.6 kg/ha + 2, 4-D 2.2 kg/ha + Atlawar post 9 kg/ha	443.9
Simazine, preemergence 2.2 kg/ha	477.5
Simazine, preemergence 6.7 kg/ha	499.6
2, 4-D pre 2.2 kg/ha 2, 4-D post 2.2 kg/ha + 3 cultivations	501.5
Simazine, pre 6.7 kg/ha + 2, 4-D post 1.7 kg/ha	612.4

Simazine, preemergence 4.5 kg/ha.	537.8
Simazine, pre 4.5 kg/ha+2, 4-D post 1.7 kg/ha twice	617.9
Simazine, pre 2.2 kg/ha+2, 4-D post 1.7 kg/ha twice	570.1
Simazin, pre 2.2 kg/ha+2, 4-D post 1.7 kg/ha twice+ 2 cultivation	619.8
Hand weeding	624.4
Simazine, pre 4.5 kg/ha+2, 4-D post 1.7 kg/ha twice+2 cultivations	664.0
Simazine, pre 6.7 kg/ha+2, 4-D post 1.7 kg/ha twice+2 cultivations	678.3

Three hoeings with bullock drawn implements increased the yield of sugarcane by about 110.7 quintals per hectare over the unweeded control. Hand weeding (4 times) recorded an increase of 120% over the control. An application of simazine at 4.5 kg (pre-emergence)+2, 4-D(Post-emergence) at 1.7 kg. twice was as effective as hand weeding. The yield of sugarcane was further increased by about 46 quintals per hectare wherever chemical control was carried out in combination with two hoeings with bullock drawn implements.

(iii) In the case of maize, 4 hand weedings stepped up the grain yield by 334% over the yield obtained from unweeded control. Application of Simazine at 2.2 kg/hectare followed by a post-emergence spray of 2, 4-D at 840.6 gm a.e. per hectare effectively controlled all types of annual weeds and nutgrass and the grain yield from this treatment was at par with that of the treatment receiving 4 hand-weedings.

(iv) Ridge planting of potato increased the yield by about 73.8 quintals per hectare over flat planting. Earthing up of the crop effected about 46 quintals per hectare increase over no earthing up. Pre-emergence application of 2, 4-D at 560 gm a.e. per hectare combined with earthing up of potato crop was conducive to higher production and suppression of weeds.

(v) Investigations on the control of nutgrass (*Cyperus rotundus*) indicated that maximum eradication of this weed was effected with 4.5 kg. of 2-4D applied per hectare in conjunction with 1 cultivations in summer and 3 during rainy season. Hot weather cultivation alone was of not much use in reducing the stand of nutgrass. Suppression of this weed increased significantly the yield of the following wheat crop over the control plot.

5. Irrigation Investigation Scheme :

Experiments on cropping patterns in relation to irrigation intensity and the irrigation requirements of wheat, potatoes, sugarcane and cotton were continued. Besides these, studies were initiated to work out the relative responses of wheat, peas, linseed and gram to irrigation.

(i) Studies on the relationship between cropping patterns and irrigation intensities indicated that the best yields were obtained with irrigation delta of 80 cms. for sugarcane, 12.5 cms. for maize, 91.25 cms. for berseem, 47.5 cms. for potatoes and 31.25 cms. for wheat. Cotton did not respond to post-sowing irrigations during the year because of the early break of the monsoon.

Studies of the different crop rotations showed that the inclusion of 'Jowar+cowpeas' in the rotations decreased the yield of the succeeding wheat crop only to a small extent and increased net returns without adding materially to the irrigation requirements. The cultivation of berseem too increased net returns but raised the irrigation requirements.

(ii) Inter-relation of varying water regimes and manurial factors on the potato crop was studied for the third year in succession. A crop of maize and cowpeas (mixture) preceded the potato crop in *Kharif*. The yield of potato obtained during 1960-61 is presented below.

Effect of water regimes and manurial factors on the yield of potatoes (qu/ha)

	K ₀	K ₁	K ₂	Mean	n ₀	n ₁	n ₂
t ₀	261	317	347	308	273	320	332
t ₁	230	274	298	267	247	293	263
t ₂	222	282	284	263	255	262	271
mean	238	291	310		258	291	289
S. Em.		±4.2	Interactions.				
P ₀	218	247	255	241	P'.K'	33.7	±7.24
P ₁	243	299	317	287	N'.T'	22.0	±11.21
P ₂	252	326	356	312	K'.T'	12.0	±11.21

n₀, n₁ and n₂ denote 56, 112 and 168 kg N/hectare respectively.

P₀, P₁ and P₂ denote 0, 56 and 112 kg. P₂O₅/hectare respectively.

k₀, k₁ and k₂ denote 0, 84 and 168 kg K₂O/hectare respectively.

t₀, t₂ and t₂ denote irrigation at about 0.25, 0.5 and 0.75 atmosphere (soil moisture tension) respectively.

'single dash' denotes linear component of the response significant at 1% level. 7.1 cms. rains was received during the crop season.

Frequent irrigation at low soil moisture tension gave substantial increase in yield as compared with delayed irrigations. The effect of frequent irrigations was enhanced by applications of nitrogen and potassium at higher rates. Phosphate and potassium increased the yields markedly. These factors showed strong positive interaction.

(iii) Studies on the relationship of irrigation, nitrogen levels and seed rates on sugarcane were continued for the second year under report. Results indicated that frequent irrigations at low soil moisture tension increased the sugarcane yields progressively, as in the previous years. Increase in nitrogen beyond 56 kg. N/hectare and the increased seed rate beyond 46 quintals/hectare did not produce any significant effect on yield. The crop was harvested late in March and this probably mitigated against the beneficial effect of nitrogen by inducing sprouting of lateral buds.

(iv) Effect of irrigating wheat at different stages of growth in relation to variety was studied for the second year. Treatment effects on the grain are given in table below.

Effect of varying moisture regimes and irrigation of different stages of growth on the yield of wheat

Moisture regime (Gypsum Block distance at 6" soil depth)	Yield of grain (qu/ha)		Yield in relation to irrigation according to stage of growth (qu/ha)			
			Flowering	Grain filling	Flowering + grain filling	
Dry (unirrigated)	18.9	Jointing	28.2	31.9	30.2	30.2
Mosit (Block mositure below 35,000 chm). ohm	30.3	Boot	27.8	26.8	28.7	28.3
Wet (Block mositure below 3,000 chm). ohm	33.1	Jointing and Boot	28.4	30.3	30.2	27.7
S. Em.	±1.47			±1.47		
C. D. (5% level)	4.19			4.19		

The irrigated crop of wheat supported by conserved moisture and the seasonal rainfall amounting to 7.25 cms. gave 18.91 quintals grain yield per hectare. The yield increased by 50% by a single irrigation at jointing stage. The second irrigation at flowering stage indicated further increase in yield. More than two irrigations did not benefit the crop materially. Irrigation at boot stage tended to give lower yield than that at jointing stage, because the effect of the former was some what masked by the rain which followed irrigation at that stage.

The two varieties did not react differentially to the irrigation treatment.

(v) Studies on the irrigation requirements of crops indicated that wheat gave the highest yield with two irrigations (17.5 cms.) and peas with three irrigations. Linseed and gram did not respond to irrigation. Furrow irrigation did not increase the yield of any of the crops but helped in economising water.

6. Plant Tissue Tests and Spray Fertilisation :

(i) The project on comparative efficiency of soil and spray fertilisation of gram (rainfed) and peas (irrigated) completed the third year of experimentation. The yield results are as under :

Treatment	Yield in quintals per hectare	
	Gram	Peas
1. Control	8.78	21.03
2. 45 kg. P_2O_5 (Soil application)	10.31	24.26
3. „ + 1.1 kg. Mo/ha	11.69	24.90
4. „ + 2.2 kg. B/ha	11.93	24.81
5. „ + 5.6 kg. Cu/ha	9.85	24.53
6. „ + 5.6 kg. Mn./ha.	9.57	23.80
7. „ (Spray fertilization)	10.73	23.70
8. „ + 1.1 kg. Mo „	9.57	23.33
9. „ + 1.1 kg. B „	10.94	22.32
10. „ + 1.1 kg. Mn „	9.18	25.09
11. „ + 1.1 kg. Cu „	9.81	26.10
12. „ + 0.28 kg. Mo „ ± 1.1 lb. B/ha	10.27	24.35

Application of 45 kg. P_2O_5 as foliar spray increased the yield of gram by 1.94 quin. per hectare which was on the verge of significance at 5% level over control. Soil application of phosphate in conjunction with 1.1 kg. Mo and 2.2 kg. B per hectare increased the yield by 2.9 and 3.15 quintals. over the control respectively. These differences were significant. In the case of peas, although the differences in yield due to different treatments are not significant there are indications that phosphate through spray or soil application increased the yields.

(ii) Soil application of 67 and 134 kg. P_2O_5 increased the yield of berseem green fodder by 46 and 129.4 quintals per hectare respectively. When $1/3$ of the total phosphate was sprayed and $2/3$ applied to soil, the respective increases in yield for these doses were 46 and 25.8 quintals per hectare over soil application. Out of the micronutrients tried viz., Mo, B and Zn, spray of zinc at 1.1 kg. per hectare in conjunction with soil application of phosphate was more effective in increasing the yield than double the dose of phosphate applied through soil. The results indicate that economy in fertiliser use can be affected through spray fertilization of berseem.

(iii) On equivalent nutrient basis, soil application of fertilisers gave higher yield of sugarcane than spray fertilisation alone or soil plus spray fertilisation.

(iv) Relative response of N.P. wheat varieties 718, 823 and 824 to Urea application at 17, 34 and 51 kg. N as soil, spray and 'soil+spray' fertilisation was studied on a light loam soil of average fertility. The yields are given below :

Yield of wheat grain in quintals per hectare

Method of application	Varieties								
	N.P. 718			N.P. 823			N.P. 824		
	Doses of nitrogen			Doses of nitrogen			Doses of nitrogen		
	17kg.	34kg.	51kg.	17kg.	34kg.	51kg.	17kg.	34kg.	51kg.
Soil application .	22.43	26.14	28.74	26.93	32.47	32.20	31.40	33.95	31.52
Spray application .	26.62	27.63	30.98	29.36	30.60	29.99	32.87	36.26	37.68
Soil + Spray application.	26.32	26.77	34.33	30.45	31.62	32.76	31.40	34.33	35.02
Mean of controls .	19.89			26.31			25.72		
'F' test for methods of application—Not significant; S. Em. ± 0.710									
'F' test for doses of nitrogen and varieties of wheat—Significant									
						S. Em. $\pm$	0.65		
						C. D. at 5%	1.92		
'F' test for controls—Significant; S.Em. ± 1.31 ; C. D. at 5%									
						S. Ed.	0.88		

On an average, spray or soil + spray application of urea gave an extra yield of about 1.84 quintals per hectare over soil application. Varieties N.P. 823 and N.P. 824 yielded significantly higher than variety N.P. 718. Increasing doses of nitrogen effected significant increases in yield. In the case of varieties N.P. 718 and N.P. 823, the response to nitrogen was linear within the range tested. The optimum dose for the highest yielder N.P. 824 was about 35 kg. of nitrogen per hectare.

(v) Rapid plant tissue tests carried out on wheat and potatoes indicated that the nutrients applied through soil and spray fertilisation were adequately utilised by these crops as shown by the intensity of colour development for phosphorus and NO_3 in plant parts.

7. Co-ordinated Agronomic Experiments Scheme :

The work of the Coordinated Agronomic Experiments Scheme which comprises of two parts namely (i) Coordinated scheme of Simple Fertiliser Trials on cultivators' fields and (ii) Model Agronomic Experiments Scheme initiated in 1956, continued during the first year of the Third Five-Year Plan. Salient features of the results obtained are as follows :

(i) *Coordinated Scheme of Simple Fertiliser Trials on Cultivators' Fields.*—The average responses of paddy to applications of 22 kg. nitrogen, phosphorus and potash were 3.6, 2.7 and 1.5 quintals per hectare respectively. Increase in the level of nitrogen from 22 to 44 kg. resulted in an average increase of about 65% over the response due to 22 kg. dose.

Under irrigated conditions, the average responses of wheat to the application of 22 kg. nitrogen, phosphorus and potash were 3.6, 2.5 and 1.8 quintals per hectare respectively. Increase in the level of nitrogen from 22 to 44 kg. per hectare effected an increase of 60% of the response due to 22 kg. level of application. The average response of wheat under unirrigated conditions to the three plant nutrients were about 50% of those under irrigated conditions.

Average responses of more than 2.3 quintals per hectare were obtained due to 22 kg. nitrogen per hectare on maize, *ragi* and *bajra* crops. Good responses to phosphate was obtained on *ragi* only while potash application of *ragi* and *bajra* crops indicated good response of more than 1.2 quintals per hectare.

Sugarcane gave good response to application of 67 kg. nitrogen per hectare, 45 kg. per hectare of phosphorus and potash each, in North India. When the level of nitrogen was increased from 67 to 134 kg. per hectare the yield was almost doubled in U.P. and West Bengal.

Good responses to all the three nutrients were obtained with potato crop. The yield increased appreciably when the level of nitrogen was doubled to 112 kg. per hectare.

Under irrigated conditions, cotton responded well to application of 56 kg. nitrogen per hectare and 22 kg. potash per hectare. The response was almost doubled when the dose of nitrogen was increased from 56 to 112 kg. per hectare.

The average response of jute was 28.4 quintals per hectare to 45 kg. nitrogen per hectare. With the increase in the level of nitrogen to 90 kg. per hectare, there was an increase of 7.2 quintals in the response. Potash at the level of 22 kg. per hectare gave a response of 13.5 quintals per hectare.

(ii) *Model Agronomic Experiments Scheme*.—Yield results of 64 experiments on paddy and 55 experiments on wheat conducted during 1959-60 were compiled during the year under report. Responses of paddy and wheat to 22 kg. nitrogen were 2.4 and 2.3 quintals per hectare respectively. Response to phosphorus was comparatively moderate in the case of paddy and no response in the case of wheat. Potassic applications showed little effect on yield of both the crops. Response to ammophos was better than that obtained with superphosphate. With wheat localised application of phosphate, gave higher response compared to broadcast application whereas in the case of paddy, method of application did not effect the response. Phosphate manuring of legumes indicated residual response on the succeeding crop of paddy and wheat at some of the centres.

Application of 22 kg. N to *jowar* gave an average response of 1.8 quintals per hectare while application of phosphate gave no response. In case of cotton, application of 34 kg. N increased the yield by 2.3 quintals per hectare while response to 34 kg. P_2O_5 was 1.3 quintals per hectare.

8. Cattle Breeding and Management :

The Sahiwal herd is being built up gradually by proper selection of good animals and culling out the poor stock. The herd strength which was 116 on 1st January, 1961 rose to 139 on 30th November, 1961 with 50 milch cows. Percentage of cows in milk was 62.6% during this period. The milking and over all averages were 10.0 litres and 6.3 litres respectively during the year.

20 cows completed their normal lactations and the average lactation yield was 3226 litres milk in 10 calendar months. However, six cows gave more than 3525 litres of milk in 306 days. The average age of heifers at first calving was 2 years, 10 months and 4 days. During this period 2 Sahiwal bulls and 1 buffalo bull were sold

9. Agricultural Statistics Section :

Research Projects

1. (a) *Genetical aspects of milk improvement in Sahiwal Herd.*—The data on dams and daughters for the period of 28 years beginning from 1932 were collected and lactation yields were tabulated progeny-wise and further statistically examined to study the improvement in milk yield.

(b) *Bulletin on Sahiwal Herd.*—Prior to the preparation of the bulletin on Sahiwal herd, a preliminary examination of the data on wet and overall averages of milk, average wet and dry periods of milking cows and lactation yields of the herd was done. In this connection, information on wet averages etc. were collected and tabulated since 1914-15 uptodate. Further the available data on cows have been collected from the old registers to make thorough scrutiny.

(c) *Bulletin on fertilisation of crops.*—The bulletin on the fertilisation of crops drafted in 1960 was re-submitted to I.C.A.R. for publication.

2. *Sampling Methods for growth characters and yield of crops.*—Studies on sampling methods for the assessment of wheat yield in experimental crops were carried out. The percentage error of the number of samples in relation to the number of rows sampled is tabulated below.

TABLE I

Percentage error of wheat samples of 180 cms. length taken from a row

No. of samples	No. of rows			
	4	6	8	10
1	10.0	9.0	7.0	6.0
2	9.9	8.0	7.0	6.0
3	9.9	8.0	7.0	6.0
4	9.9	8.0	7.0	5.9
5	9.9	8.0	7.0	5.9

TABLE II

Percentage error of wheat samples of 120 cms. length taken from a row

No. of samples	No. of rows			
	4	6	8	10
1	11.0	9.0	8.0	7.2
2	8.0	7.0	6.0	5.0
3	7.0	6.0	5.0	4.4
4	6.0	5.0	4.4	4.0
5	5.6	4.7	4.0	3.6

The results indicate that a sample of 6 ft. length was not sufficient to estimate the plot yield. Sampling units of 4 ft. length with two cuts per row from at least 6 rows of wheat per plot (18' × 16') indicated a sampling error of 5% in the estimation of wheat yield.

3. *Crop cutting Experiments in the villages of the Intensive Cultivation Scheme attached to I.A.R.I.*—The crop cutting experiments during Rabi 1961 were conducted in the villages of the Intensive Cultivation Scheme I.A.R.I. with a view to estimate and compare the performance of N.P. 718, N.P. 823, N.P. 824 and C. 281 varieties of wheat. The results based on 28 cuts of 1/80 acre size each are presented below:—

Varieties	Yield (qu/ha)	S. Em.	%S. Em.	Difference
N. P. 823	23.67	±2.48	10.48	4.32
N. P. 824	19.35	±3.21	16.59	3.84
N. P. 718	19.83	±2.37	11.95	4.67
C. 281	19.00	±1.73	9.13	0.48
				0.35
				0.83

Variety N.P. 823 yielded the highest but the differences over yields of other varieties were not significant.

4. *Statistical analysis of data from various Divisions.*—Data from thirty three experiments of the following Divisions of the Institute were analysed statistically and the results sent to the respective Divisions.

Divisions	No. of experiments
Agronomy & Agril. Sub-station, Karnal	24
Agricultural Extension	2
Chemistry	3
Entomology	2
Mycology	2
TOTAL	33

10. Agricultural Research Sub-station of I. A. R. I., Karnal :

Research Projects

(i) Residual effects of manures and fertilisers applied to cotton and maize grown in cotton-fallow-maize-wheat rotation were studied on wheat. The results indicated that the increased yield of wheat due to an application of 68 kg. N was significant over the control. There were no differential residual effects due to varying doses of phosphate, potash and farmyard manure.

(ii) Tillage-cum-manurial and fertiliser experiment on wheat was continued for fifth year in succession. The yield results are given below :

Treatments	Yield of wheat (qu/ha)	
<i>Cultural</i>		
(X) Tractor and allied implements	17.06	
(Y) Victory-cum-country plough	19.28	'F' test Not Significant.
(Z) Country plough	18.45	S. Em. ± 0.83 .
<i>Fertilisers (Phosphate)</i>		
P ₀ —Super (nil)	15.13	'F' test Significant.
P ₁ —34 kg. P ₂ O ₅ /hectare	21.40	S. Em. ± 0.28
		C. D. at 5% = 0.83
<i>Fertilisers</i>		
No manure	12.9	'F' test Significant.
Amonium sulphate at 68 kg. N/ha.	19.1	S. Em. ± 0.55
F.Y.M. 68 kg. N/ha.	17.9	C. D. at 5% = 1.57
Ammonium sulphate at 34 kg. N+ F.Y.M. 34 kg. N./ha.	23.1	
G. M. (S. hemp)	19.0	
G. M. (S. hemp.) $\times$ 34 kg. N/ha. as ammonium sulphate	19.4	
Ammonium Sulphate at 34 kg. N/hectare	18.1	

Wheat showed no differential response to cultivation by tractor or bullock drawn implements. Application of nitrogen and/phosphorus at 34 Kg./hectare affected significant increases/in yield. On equivalent nitrogen basis (68 Kg.), a combination of ammonium sulphate and farm yard manure at 34 Kg. N each was superior to either of them alone as well as to green manuring with *sann hemp*.

(iii) Results obtained for an experiment on the transplanting of the six New Pusa varieties of wheat (N.P. 710, 718, 823, 824, 798 and 835) indicated that variety N.P. 718 yielded the highest (31.59 quintals per hectare) followed closely by N.P. 824 (29.41 quintals per hectare). Nursery sown on 18th October and transplanted after 30 days produced significantly higher yield than nursery sown at fortnightly intervals 45 days of sowing. A dose of 68 kg. N to the transplanted crop on an average, increased the yield by 2.83 quintals per hectare over that due to 34 Kg. N application. This increase was significant.

Agricultural Economics Section.—The investigation conducted consisted of studies on (a) Farm Economics (b) Cost of production of crops (c) Agricultural Marketing and Prices and (d) Agro-economic surveys. Generally speaking, the size of the family and the available family labour force rose with increase in holding size. For size-groups less than 2.0 hectares, 2.4 hectares, 4.6 hectares and 6 hectares and over respectively, the available adult male equivalents of family labour were 4.5, 8.2, 7.6 and 7.1, the corresponding 'per hectare' adult male equivalents being 3.0, 2.7, 1.5 and 0.7 respectively. For holding sizes in the same order, investment in fixed capital ranged from Rs. 9,243, 17,849, 22,599 to Rs. 47,521, and per hectare investments were Rs. 6,402, Rs. 5,765, Rs. 4,781 and Rs. 4,861 respectively. The slight excess of per hectare investments in the highest size group over the 4-6 hec. group was due to higher values of land and cattle sheds; even so, the economics of scale in fixed capital are clearly revealed.

Results of studies on farm business of holdings grouped in the same order are given below :

Expenditure and returns on cultivator's holdings 1959-60

(Rupees per hectare)

Size group (hectare)	Gross Expen- diture	Gross return	Net return	Family labour income	Farm business income
A—Crop Enterprises alone					
0—2	796·96	847·57	50·61	246·07	501·62
2—4	784·09	945·47	161·38	332·33	557·27
4—6	686·63	857·78	171·14	323·31	543·14
+6	654·09	778·65	133·56	248·39	469·82
B—Crop+Livestock Enterprises combined					
0—2	2,057·50	1,469·88	887·62	17·10	332·65
2—4	1,487·87	1,329·47	158·39	215·20	474·09
4—6	1,169·33	1,180·72	11·39	254·74	501·25
+6	899·54	924·17	24·64	176·09	406·44

Gross expenses tended to decline and net return, family labour income and farm business income tended to rise with increase in holding size. When imputed value of family labour was taken into consideration and crop and livestock enterprises viewed in combination, per hectare figures for family labour income ranged as Rs. 17, 215, 255 and 175 respectively while corresponding figures for farm business income were Rs. 334, 474, 502 and 413 respectively. The possibility of effecting considerable improvements in the farm budget through improvements in the quality of milch stock and rationalisation of standards of feeding them was revealed from these studies. It was also obvious that holdings below 4-6 hectare size were too small to make a harmonious balance between land and livestock on the farm under existing agro-technical situation.

Cost of production of crops.—Cost of production studies were continued for kharif season 1960 crops Bajra and jowar (fodder) and wheat and gram crops 1960-61. Per hectare costs of cultivation declined as holding size rose from Rs. 343, 282, 235 to 210 with bajra grain and Rs. 388, 329, 277 to 294 respectively with fodder jowar. In the case of wheat, physical inputs of human labour per hectare declined from 106, to 106, 91 and 67 respectively; those of bullock labour from 57 to 54, 44 and 35 respectively and value per hectare of materials used fell from Rs. 104 to 67, 52 and 54 respectively as size of holdings rose. Similar figures for gram were : physical units of (a) human labour per hectare—40, 35, 22, 20 (b) bullock labour—15, 10, 7 and 5 and (c) value per hectare of materials used Rs. 20, 22, 20 and 20 respectively.

Agricultural Marketing.—Observations on sales and purchases effected 1960-61 of farm produce on farmers' holdings showed that the area (Intensive Cultivation Block attached to the Institute) as a rule is deficit in gram production. Marketed surpluses were observed with respect to other items. The surpluses which were meagre in the smaller holdings tended to rise sharply as the size of holding increased. For size-groups arranged in ascending order as before, the annual marketed surpluses were respectively, 29·4, 14·4, 280 and 591 quintals for wheat; 66·4, 96, 93·3 and 101 quintals for gram; 5·2, 16·8, 41·8 and 60·5 quintals for *bajra*, *jowar* and *guar* lumped together and 27·2, 24·6, 121·7 and 308·3 quintals respectively in respect of *gur* (and *shakkar*). Indications were also available of the ability in respect of higher sized holdings to time their sale of *gur* so as to synchronise with periods of higher prices.

Agro-economic Surveys.—In the agro-economic surveys, crop patterns and intensity of cropping etc. were studied on cultivators' holdings. As the size of holdings rose, the percentage of cropped area under *bajra* fell from 14.2 hec. to 10.5 hec. to 11.7 hec to 9.3 hec., that under fodders fell from 2.8 hec. to 2.0 hec. to 1.6 hec. to 1.6 hectare while the corresponding percentage under wheat (and gram) etc. in the *Rabi* season rose from 44 to 50 to 51 and the decline in cropping intensity recorded was 140 to 127 to 119 to 122 in the respective size groups.

The food consumption patterns were also observed on the holdings. Higher quantities, particularly of pulse, vegetables and *gur* were found to be associated with higher sizes, the increase in quantities being reflected in higher volume of expenditure.

PROGRAMME OF WORK FOR 1962

1. *Soil Fertility Section:*

- (i) Building up of soil fertility through organic manures and inorganic fertilizers.
- (ii) Phosphate fertilization of legumes.
- (iii) Soil fertility studies through crop rotations and use of manures and fertilizers.
- (iv) Experiments on mixed farming.

2. *Field Crop Section:*

- (i) Response to manures and fertilizers.
- (ii) Varietal and cultural trials.
- (iii) Agronomic studies on grasses and legumes with special reference to their suitability for pasture management and development.
- (iv) Grassland Scheme (I.C.A.R.)

3. *Vegetable and Commercial Crop Section:*

- (i) Response to manures and fertilizers.
- (ii) Cultural and Varietal trials.
- (iii) Vegetable growers 2½ acre holdings.

4. *Farm and Cattle Development Section:*

- (i) Line breeding and selection for improvement in milk yield.
- (ii) Feeding of stock on balanced ration for optimum growth.
- (iii) Rearing of pail-fed calves on skim milk antibiotic waste products and urea.
- (iv) Mixed Farming Experiment.

5. *Projects under Third Five-Year Plan:*

- (i) Irrigation Investigation Scheme.
- (ii) Weed Control Investigation Scheme.
- (iii) Plant Tissue Tests and Foliar Spray fertilisation scheme.

6. *Agronomic Experiments at B.S.S., Pusa.*

- (i) Permanent Manurial and rotation experiment.
- (ii) New Manurial Experiment.

7. *All India Co-ordinated Scheme of Fertiliser Experiments:*

- (i) Model Agronomic Experiments.
- (ii) Simple Fertilizer Trials on Cultivators' Fields.

DIVISION OF AGRICULTURAL ENGINEERING

(Shri E. G. K. Rao)

RESEARCH PROJECTS

(1) **Bullock Drawn Seed-Drill.**—Based on a design received from the T.C.M. Greece a 4-row multipurpose seed-drill has been developed in the Division. Preliminary trials carried out in collaboration with Agronomy Division have shown satisfactory performance. The seed rate for wheat was maintained at 35.6—36.4 Kilo/Acre. The draft recorded was 170—180 lbs.

(2) **Automatic Jute Seed-Drill.**—In order to develop a simple cheap and efficient seed-drill, four sets of a commercially available hand pushed jute seed-drill have been mounted on a common shaft.

(3) **Animal Drawn Disc-Harrow.**—An animal drawn off-set disc harrow has been under development in this Division. During the preliminary trials, it was found to be capable of working in local soils upto a depth of 4", with an effective working width of 36". It offered a draft of 250 lbs. and gave an output of 2½ acres per 6 to 8 hours.

(4) **Hand Hoe.**—A novel design of multipurpose hand hoe has been developed and trials with prototype hoes manufactured in the Division have evoked considerable interest. An application for patent has been filed and negotiations for its large scale manufacture are being undertaken by N. R. D. C. The implement shows great promise.

(5) **Investigations of water logging problems at the I. A. R. I.**—Periodical checks of water levels of all the wells in the I. A. R. I. Estate and the effects and water carrying capacities of surface drains are studied. During these studies a new method of ascertaining the hydraulic gradient and division has also been evolved.

(6) **Design Installation and Evaluation of tile Drainage Project.**—Water table observations are taken at fortnightly intervals. Discharge from the tile lines laid out is also observed. Construction work for shaping of open drains and laying out additional tile lines has also been undertaken. In 1961 the project has started working in the middle of July. Till August all the lines were working but after rains tile lines No. 1 and 2 in Shadipur Area stopped discharging. The channels which had been damaged are being cleared and fresh surface drains are also being dug. During 1961 tile line No. 4 and an 80 ft. portion of tile line No. 3 in Shadipur Area were constructed. As a result sub-soil water as well as surface drainage was substantially improved in Block No. 4 and Shadipur Area as compared with other fields. The water table curve plotted from data observed weekly shows that the water table in the tiled area has been lowered substantially to depth of 6 ft., which is 2½ ft. lower than the control plots.

(7) **Water Measuring Devices.**—(i) *Parshall Flumes.*—Parshall Flumes of different throat widths were introduced in the I.A.R.I. Estate. Up-till-now 6 Nos. of 3" Parshall Flumes have been fabricated in the R. T. C.

Wooden forms for constructing the flumes in concrete have been fabricated.

(ii) *W. S. C. Flume.*—This flume is much simpler than the stream flows.

(8) **Contour Bunding in the Todapur Area.**—A set of three contour bunds was designed for a part of Todapur Area. The bund No. 1 was completed during summer of this year and bund No. 2 has been constructed except for the last 200 ft.

(9) **Single Bullock Harness.**—With basic data obtained from a recent F. A. O. publication a three pad harness was fabricated in the Division's Workshop and tried in the field. The harness is made mainly of two wooden shoulder hames inside and three leather or canvas pads. The results have been quite encouraging and the harness is quite cheap in cost. In field trials, one large size bullock was able to record pull of 400 lbs. with this improved hitch. The hitch enables animal's body weight to be used more effectively. The device holds out promise for more effective utilization of animal power for agricultural operations.

TESTING AND STANDARDISATION

(1) **Testing of Power Sprayer Duster.**—A knapsack sprayer-cum-duster, 'Gloria' of German manufacture brought in by M/s Services and Supplies, New Delhi is under going tests in order to find out its suitability for plant protection and weed control operation under Indian conditions. It is a low volume sprayer operated with a two stroke-cycle engine of 1.6 H.P. manufactured by M/s Sachs Motors of Germany. The spraying unit is adaptable to a wide variety of uses such as spraying, misting, dusting and flume throwing for destructions of weeds and pests in otherwise inaccessible places.

(2) **Test of Labour Tractor.**—A 5 H.P. Labour Walking Tractor made in France was tried in the Institute Farms at the instance of M/s Ghaziabad Engineering Co. Ltd., New Delhi. The tractor was supplied with a two-way plough, a three tined cultivator, a 2 row planter, a mower and a set of blade hoes. All the implements except the planter which was studied in the workshop, were put to field tests. The tractor was worked for a total of 32 hours. The quality of work done in various field operations was notably superior to that of the bullocks. The operations called for some considerable skill but not beyond the scope of an average skilled mechanic. It is felt that the tractor in its present form would not be very useful under the Indian condition.

PROGRAMME OF WORK FOR 1962

- (1) Development of Bullock-Drawn Seed-Drill and Feed Cultivator and Seed-Drill (*contd.*).
- (2) Development of a Bullock-Drawn Fertilizer placement machines (*contd.*).
- (3) Development of an animal drawn Disc-Harrow.
- (4) Development of heating and lighting appliances for use with cow-dung gas plant.
- (5) Development of a Jute Seed-Drill.
- (6) Development of Dibbler.
- (7) Study of water logging and rise of water table at I. A. R. I.
- (8) Study of various modern methods of irrigation and their efficiency in co-ordination with Division of Agronomy.
- (9) Testing of Agricultural Implements and Machines for use under local conditions.
- (10) Testing of Japanese Implements received in the Division under regional conditions.
- (11) Any other work suggested by the Ministry.

DIVISION OF AGRICULTURAL EXTENSION

(Shri A. R. Khan)

1. INTENSIVE CULTIVATION SCHEME IN DELHI VILLAGES.

(i) During the period under review one hundred and fifty one 'Result Demonstrations' with improved varieties of wheat, bajra and maize along with the use of fertilisers and other improved practices were carried out in the villages of Kanjhawala Block. The average yields obtained in 14 villages with the new wheat varieties, namely, NP 824 and 823, were 24.0 mds. and 23.9 mds. per acre respectively as against 21.7 mds. obtained with one of the old and established varieties, N.P. 718.

When these varieties were compared with another old variety in 10 villages the per acre yields recorded in mds. were as follows :

NP 824	.	.	.	.	20.6
NP 823	.	.	.	.	19.6
C 281	.	.	.	.	18.6

(ii) **Introduction of green fodder.**—In order to popularise the cultivation of green fodder crops in the villages, eighteen demonstration plots, one in each village, were sown with berseem. Since the introduction of this fodder in previous years, it is getting popular among the farmers.

(iii) **Introduction and use of improved implements.**—During the period under report four improved chaff cutters and five soil turning ploughs were kept continuously for demonstration purpose in the villages. A demonstration on the working of paddy thresher was given in the Gheora village. Fifty 'Tirphalis' were used for demonstration in the villages.

(iv) **Supply of seeds and plants.**—About 800 mds. of wheat seeds NP 823 were made available to the cultivators by the various Co-operative Societies located in the Kanjhawala Block.

Fifty mds. of pedigree wheat seed of NP 823 were supplied to ten 'A' class farmers. In addition to this, the following seeds were also arranged for farmers.

	Crop	Quantity
1.	Sugarcane (CO 312)	20 mds.
2.	Tomato (Pusa Ruby)	80 lbs.
3.	Chillies (Long)	15 lbs.
4.	Cowpeas	5 lbs.
5.	Brinjals (Pusa purple long)	20 lbs.

In order to encourage the planting of fruit trees in villages the following plants were supplied.

1.	Papaya	650
2.	Guava	1,170
3.	Lemon	411
4.	Mulberry	9
5.	Mangoes	117
6.	Shady plants	112
TOTAL		2,469

(v) **Plant Protection.**—A campaign against termites was launched and an area of 151 acres was treated suitably in the various villages of Kanjhawala Block. About 300 mds. of NP 823 and NP 824 wheat seeds were treated with Agrosan GN against soil and seed borne diseases. Demonstrations were also given for the control of rice fly and nematodes that damage chillies and tomato plants in the villages of Kanjhawala Block.

(vi) **Miscellaneous.**—Ten seed farms were established in the villages of Kanjhawala Block. They have grown NP 823 wheat in a consolidated block of five acres each.

One hundred and eighteen compost pits were dug up in the villages of Jonti, Nilwal and Chatesar.

As a result of the work done by the Extension staff to popularise the cow-dung gas plants in villages, 21 applications from farmers who are keen to get the plants installed in their premises were received and forwarded to the Development Commissioner Delhi, for necessary action.

2. SCHEME FINANCED BY THE MINISTRY OF FOOD AND AGRICULTURE

Key Village Scheme.—Efforts were made to popularise the artificial insemination of cattle amongst the farmers. Regular supplies of semen were also made to the Veterinary Department Delhi. In addition to this, the following work was done in various centres of the Key Village Scheme.

1. No. of cows served naturally	134
2. No. of Buffaloes served naturally	414
3. Castrations performed	70
4. Animals treated	464
5. No. of A. C. performed :—	
Cows 12+12	24
Buff. 25+77	102
6. No. tested for pregnancy :—	
Cows	26
Buff.	44
7. Animals tested for sterility	46
8. Vaccinations performed	731

PROGRAMME OF WORK FOR 1962

1. Research :

Projects on 'Extension Methods' will be intensified as soon as the staff is in position.

2. Development :

A scheme for increasing agricultural production in the N.E.S. block Kanjhawala of Delhi Admn. has been started during *rabi*, 1961. Ten farms, one in each of the V.L.W. circle, have been established. They will serve as a 'whole farm demonstration' for showing technological advance suitable to the area. Work through extension teaching methods for the quick adoption of the innovations will be taken up.

3. Teaching :

Post-graduate training for Master's and Doctor's degree in Extension will continue to be given as heretofore. The scope of the subjects will greatly be enlarged with the appointment of specialists.

DIVISION OF BOTANY

(Dr. M. S. Swaminathan)

The research work of this Division, which primarily aims at the production of superior varieties of crop plants through the application of modern techniques of plant breeding was continued during the year under the four sections : Plant Breeding and Genetics, Cytogenetics, Crop Physiology and the Plant Introduction and Exploration Organisation. Experimental work of basic nature in the field of genetics, the science which provides the basis for modern plant breeding methods, was intensified in the Fundamental Plant Genetical Research Laboratory set up in this Division during the Second Plan

The period under review was marked by the strengthening of the laboratory facilities for seed testing work, made possible through the generosity of the Rockefeller Foundation which made available several pieces of modern equipment for this purpose. A 6-week training course in this specialised field was organised in the Division at the instance of the Ministry of Food and Agriculture and with the co-operation of the Rockefeller Foundation and The T. C. M. Fourteen trainees from Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, Bihar, Punjab, Orissa and Rajasthan attended the course and lectures were given on different aspects of seed testing and certification by Dr. A. S. Carter, Seed Consultant to the Government of India, and other experts. Another highly specialised facility for crop improvement work with the application of atomic energy, which recently became available in this Division with the setting up of a Gamma Garden, was made available to Scientists from all parts of the country. The experimental material irradiated on requests from universities and other scientific institutions included several groups of plants, such as cereals, millets, fibre crops, spices, coconut and other oil yielding plants and many horticultural species.

In recognition of the valuable work done so far by the Plant Introduction Section, which had its modest beginnings in this Division in 1946 under an I. C. A. R. Scheme, the Government of India decided to raise the status of this section to that of a Division of the Institute with effect from October, 1961. The work on genetic variability in algae which has been in progress at this Division since 1956 was also transferred in October this year to the Division of Microbiology set up under the Third Plan.

A. PLANT BREEDING AND GENETICS

(a) Improvement of Indian wheats

Experimental work on the development of wheat varieties which combine a high yield potential with good grain quality and resistance to rusts, smuts and other diseases has been in progress at Delhi and at the five substations of the Division at Simla, Bhowali, Pusa (Bihar), Indore and Wellington (Nilgiri Hills). The breeding programme at Indore and Wellington has been planned to meet the requirement of those areas in the country which grow the tetraploid species (*T. durum* and *T. dicoccum*) where as the other substations and the more extensive studies at Delhi aim at the improvement of the common bread wheat (*T. aestivum*).

(1) **Yield trials of improved wheat varieties evolved for different regions.**—Regional testing of newly evolved N.P. wheat varieties for different tracts of the country was carried out on an extensive scale. Separate sets of varieties were tested in the North Indian hills (*aestivum*), North-Indian plains (*durum*s and *aestivum*s) and peninsular India (*dicoccum*s and *aestivum*s). Some of these varieties have been tested for over three seasons now and it became possible to make several recommendations.

(i) *N. P. 818 and N. P. 829—two new wheats for the Jammu and Kashmir hills.*—N.P. 829 and N.P. 818 have given on an average 53 and 50% higher yields than the local controls in the Jammu province. The performance of N.P. 824 has been equally impressive in the Srinagar province, where it out-yielded the controls by as much as 50%. Both the varieties possess good grain quality and a substantial measure of resistance to all the three rusts.

(ii) *N. P. 825—a new improved wheat for Uttar Pradesh and North Rajasthan.*—Observations based on 21 trials conducted during the last season have shown that N.P. 825 was superior to the existing varieties under cultivation in Uttar Pradesh in a majority of the tests. It out-yielded the controls in 15 trials, equalled them in one, and yielded less than the local checks in five of the trials. This performance of N.P. 825 was consistent with its previous record. The controls against which it was tested included such well known wheat varieties as C.13, C.273, C.281, C.591, R.S. 31-1, N.P. 710, N.P. 718 and N.P. 720. N.P. 825 has also consistently out-yielded C. 591, the prevailing variety in the region, in trials conducted in northern Rajasthan during the last three seasons.

(iii) *N. P. 832—an improved wheat variety with pissi type of grain.*—At the Indore substation, studies planned for the improvement of *pissi* type wheats under cultivation in Malwa region, have resulted in the production of a superior new variety, N.P. 832. In extensive tests during the past four seasons under both irrigated and rainfed conditions, N.P. 832 has invariably out-yielded the existing varieties such as Hyb. 11, Hyb. 65, and N.P. 710. The variety has been bred from a cross of *pissi* local with a black rust resistant Kenya wheat and possesses, apart from high yield, good grain quality and a considerable measure of tolerance to rust attack.

(2) **Assessment of material for rust resistance.**—Nearly 4,600 promising selections and standard types including the derivatives from several hybrids developed at this Division, some of the Indian improved varieties and material from the International Rust Nursery of the U. S. D. A., were critically tested in the field at adult stage, and a number of them also in the glass houses, at the seedling stage, under artificially controlled conditions of infection with individual races or a mixture of known races of the three rusts. Several of the *dicoccum* selections were found to be resistant in the seedling stage to 14 out of 16 races of black rust and to all the 13 races of brown rusts, prevalent in India. Selection H. W. 39-5-11-412-3-9 which is resistant to all the races of black rust has been found in preliminary tests to give yields superior to N.P. 200, a variety now under distribution. Another important result from this study was the isolation of improved rust resistant *durums* (varieties N.P. 40, N.P. 803, N.P. 804, N.P. 805, N.P. 806 and N.P. 409 at the Indore substation. These varieties showed resistance in the seedling stage to as many as 10 to 13 races of black rust out of the 16 races against which they were tested. A high degree of resistance was also shown by several *aestivum* selections. Thus, selections H.D. 58-312, H.D. 58-338 and H.D. 58-310 were resistant to 15, 14 and 13 races of black rust respectively; and selections H.D. 58-366, H.P. 27-156 and H.D. 58-397 resistant to 12, 12 and 8 races of brown rust respectively. Several other selections were resistant to as many as nine races of the yellow rust out a total of 10 races met within the country.

(3) **Evolution of improved tetraploid wheat varieties—Breeding rust resistant *dicoccum* wheats for Peninsular India.**—The wheat breeding substation at Wellington had earlier developed an improved strain of *Sambha* wheat, N.P. 200, which was superior to local varieties in productivity, rust resistance, and grain quality. Hybridization studies for further improvement work were taken up and N.P. 200, local *Sambha*, I.C. 1057, I.C. 1131 and other types were crossed with indigenous and exotic *dicoccums* (Abyssinian 2774) and *durums* (ex Arabia). A number of strains have been developed from these crosses which combine very high degree of resistance to both black and brown rusts. Some of them simultaneously showed resistance to all the Indian races of the two fungi. One of these selections out-yielded N.P. 200 in preliminary yield trials.

(4) **Genetic studies on disease resistance.**—Useful information on the genetic determination of reaction to rusts, loose smut and bunt disease has been collected as a result of several inheritance studies. It has been shown that the factors controlling field resistance to brown rust in the varieties Frondoso and *Laprevision* are different from those governing the same reaction in Gabo, Kenya E-1951, Timstein derivatives (E. 871) and Frontiera. Non-identical nature of genes determining resistance to black rust was also observed in varieties N.P. 790, Yaqui-53 and Kenya 184 P2 A.I.F.

(5) **Studies on grain quality.**—Fifty two newly evolved strains of hybrid origin bred at this Division and six other improved varieties were tested for the different characters of their grain, under two levels of soil fertility and two sowing dates. Based on their mean protein content, these varieties were divided into 3 groups (1) low (below 10% protein), (2) Medium (10 to 12%) and (3) high (above 12%). These results have been considered along with the yield data and selections made for types showing both high yield and good grain quality. A study was also conducted to find out the effect of mottling on the quality of wheat grains. It was found that the gluten and protein content were markedly lower in the mottled grains compared with the corresponding values in the flinty grains in variety N.P. 718. The quality sedimentation value, wheat meal-fermentation time value and gluten solubility per unit gluten, however, were not affected as a result of mottling.

(b) Barley

Ten new strains developed through a hybridization programme were tested in small scale trials at Delhi, Karnal and Pusa. At Delhi, several of these strains including BHD-60-8 and BHD-60-9 (6-rowed types) and IID-60-4 and BHD-60-5 (2-rowed types) were found to be statistically at par with the best control variety N.P. 13. BHD-60-8 gave 18.7 per cent higher grain yield than the best control variety K. 25 at Karnal and 8.7 per cent higher than the best control variety BR 22 at Pusa. All these strains show better grain quality than the existing recommended varieties—N.P. 13 and N.P. 21. BHD-60-4 and BHD-60-5 in addition have been adjudged very suitable for the manufacture of pearl barley. Weider (E.B. 715), an exotic variety appeared suitable for direct introduction as it significantly out-yielded the best control variety N.P. 13 in a trial conducted at Delhi. The variety possess attractive grain and showed resistance to leaf rust.

With a view to isolate rust resistant genetic stocks, 1038 exotic and 345 Indian barleys were tested against a mixture of races of the three rusts under artificially created rust epidemic conditions. None of the Indian types was found to be resistant to any of the three rusts. A number of exotic varieties, on the other hand, including black hulless (E.B. 731) Sexonia (E.B. 158) German Brewing (E.B. 761) Letchteler (E.B. 772) Hanna (E.B. 732), Kreta (E.B. 857), Fsaria (E.B. 873) (2-rowed barleys) and Ugaru (E.B. 894), Umato (E.B. 906), Ebstorfer Nachtgerste (E.B. 905) and Glatgrannige von vilmorin (E.B. 919) (6-rowed) showed field resistance to yellow rust both at Delhi and Wellington. Earlier only two sources of yellow rust resistance, viz., varieties E.B. 410 and E.B. 438 were available as donor parents. A number of crosses with the above named yellow rust resistant genetic stocks were attempted for transferring their field resistance into the Indian commercial varieties.

(c) Maize

(i) **Advanced trials with the four recently released maize hybrids.**—The four Indian hybrids with flintish grain type, acceptable to Indian farmers, evolved under the Coordinated Maize Breeding Scheme for which this Division is the main centre, were tested on an all India basis in cooperative yield trials, along with other experimental double crosses and local checks. The Ganga Hybrid Makka 101 recommended for Northern plains gave good performance in trial demonstrations as well as in farmers' fields. On an average, this hybrid has out-yielded the local checks by 55.9%.

Ganga Hybrid Makka 1 out-yielded local checks by 21.8% while the other two, Ranjit and Deccan have given increased yields of the order of 42.5% and 50.3% respectively. These results have also shown that the four hybrids show a very wide adaptability. The Ganga Hybrid Makka has shown comparatively less increase over the locals but since it is made up entirely of Indian lines and is an early type, it may be more suitable for such areas where earliness is a very important factor. The ten inbred lines going in the production of these four hybrids have been released to the I.C.A.R., under whose control the foundation seed is being multiplied.

(ii) **Breeding for corn borer resistance.**—Studies undertaken on the resistance of the inbred lines of maize to *Chilo zonellus* have enabled to screen out ten lines of North and South American origin, that are relatively more resistant to the top shoot borer than the Indian material. These studies have further indicated that the resistance is polygenic in its genetic determination. Synthetic varieties are being developed from the above lines. It is proposed to carry out recurrent selection with a view to bringing together the genes for resistance.

(d) Essential oil bearing plants

In the programme of work on the improvement of essential oil bearing plants, selection studies for increased yield as well as high essential oil content were continued. A number of types giving 100% or more increased yields and showing higher oil content than the locals were isolated in the previous years in *ajwain*, dill, *dhania* and *sonf*. During the present year a study of the association between yielding ability and essential oil content indicated that though there was some negative association between the two, they were not mutually incompatible. Selected types were grown at two centres, Delhi in the plains and *Katrain* in the hills, in order to study the relationship of environment and essential oil content. It was observed that the conditions in the plains were less favourable leading to a lower essential oil content in the same type than at *Katrain*. Interestingly enough, the selections for higher essential oil content showed a greater decline in oil content in the adverse environment of the plains. Studies are underway to see if selection for high oil content in *ajwain* has any adverse effects on the quality of the essential oil.

(e) Spices

In chillies (*Capsicum annum*) a quantitative analysis of capsaicin content in a number of N.P. types under distribution has been undertaken. Capsaicin content in the fully ripe fruit was estimated by u.v. absorption spectrophotometry after the alkaloid was partitioned out of the crude extract by chromatography. Among the types examined N.P. 41 had capsaicin content of 71.5% and N.P. 43, 70.30%, both on the whole fruit basis. Since in chillies capsaicin is mainly present in the placenta, the proportion of the placenta in the fruit of the various N.P. types as well as the percentage of capsaicin content for unit weight of placenta were analysed. This analysis showed that capsaicin content in the whole fruit depends on the interaction of the two component characters which appear to vary independently and may be controlled by genetic system. A study of the genetic variability and heritability of capsaicin content as well as its component sub-characters indicated that considerable genetic variability is present even among the limited number of types studied.

(f) Vegetables

Further progress was made in the hybridization programme relating to the utilization of exotic and indigenous stocks in vegetable improvement. In tomato, hybrid 14, a selection from a cross made earlier between 'Meeruti' and 'Red Cloud' (American) significantly out-yielded 'Pusa Ruby', a recommended variety. Encouraging reports have been received on this selection from Sabour, Kanpur, Poona, and Pachmarhi.

It is typically a determinate type and is earlier than 'Pusa Ruby' by about 8 days. In the case of vegetable *guar*, a new selection has been made which produces large thick pods and like 'Pusa Sadabahar', the present recommended variety, can be grown in spring as well as the rainy season. An important feature of this selection is that unlike 'Pusa Sadabahar', it is capable of withstanding excessive moisture during rains. The per plant yield of the selection was 65 percent more than that of 'Pusa Sadabahar', although the number of pods per plant was reduced by 10 percent. From the cross between 'Early Badger' and 'Asauji' varieties of garden peas, a new selection, which is earlier than the popular main season variety 'Bonneville' by about 15 days and produces more attractive well filled pods, reached the shape of uniformity. Steps have been taken to multiply the selection for further trials.

(g) Forage plants

Three strains for dryland pasture production and one for intensive fodder cultivation have been developed as described below.

(i) **Pusa Giant Anjan.**—This strain is a hybrid between clones of *Cenchrus ciliaris* from Rajasthan and *Pennisetum ciliare* from the U.S.A. It produces about twice as much forage as the parental species. In addition to its high forage yields, it possesses the advantage of being more soft and succulent as compared to the existing anjan types. Another striking feature of this strain is that it produces most of its forage during the spring and hot season, which is a fodder scarcity period.

(ii) **Leafy Dwarf Blue Panic (*Panicum antidotale*).**—Blue panic grass is well known for its drought resistance and poor quality because of its too woody stems and fewer leaves. The new strain, a hybrid between a Rajasthan and an Australian blue panic clone is remarkably leafy possessing at the same time succulent stems. Its low height makes it better suited for grazing purpose.

(iii) **Pusa Selection (*Pennisetum pedicellatum*).**—This strain developed through selection, yields about 50,000 lbs. of green forage within a period of 4 months (July to October) as compared to nearly 30,000 lbs. obtained from the existing types. Apart from high forage yield it is characterised by more leaves and less stems and has relatively longer growth period.

(iv) **Pusa Giant Napier.**—This strain has been developed from a hybrid between bajra (*Pennisetum typhoides*) and a related species (*P. purpureum*). Under conditions of cultivation, it produces as much as 2,50,000 lbs. of green forage in a year as compared to about 1,00,000 lbs. obtained from Napier grass varieties. Besides, it has a high protein content (20%) and is softer and more succulent than Napier grass.

B. CYTOGENETICS

(a) Performance of induced awned mutants in wheat

The yielding ability of the fully awned mutants isolated in the irradiated populations of the awnless wheat varieties N.P. 797, N.P. 799 and N.P. 809 was again tested during the *rabi* season of 1960-61. The performance of these mutants is indicated below; their yield has been expressed as percentage of the control.

(i) **N.P. 797.**—Yield trials were conducted at Delhi and Pusa; Cultures 185-M, 1-5-17, 7-9-0 and S.P. AM. yielded 127.3, 117.80, 101.10, and 112.7 respectively at the Delhi centre. Awned mutant SP A.M. yielded 105.88% in the trial conducted at Pusa.

(ii) **N.P. 799.**—In a rod row trial of some cultures of awned mutants of this variety, which were selected during the last season for higher tiller number, cultures 2, 3, 18 and 21 yielded 138.30, 148.51, 151.55 and 138.30% respectively. These cultures have been included in a major yield trial at Delhi planned for 1961-62 season.

(iii) **N.P. 836.**—N.P. 836, the newly developed awned variety of induced mutant origin, from seeds of awnless N.P. 799, was included in trials at Pusa, Darbhanga dholi (Muzaffarpur) and at Burdwan and Malda in Bengal. It maintained its superiority over the parental type as regards yield at all the centres, both under rainfed as well as irrigated conditions.

(iv) **N.P. 809.**—In trials conducted at Bhowali, N.P. 809-A₆ continued to give higher yield than the parental type, as in the previous years. A₆ and A₉ yielded 106.32 and 97.85 respectively. A.M.6 was multiplied on a small scale at Bhowali for further trial in hilly regions.

(b) Monosomic analysis in wheat

Further progress was made in the establishment of a monosomic series in the wheat variety, C.591. The 21 different monosomic lines from the cross Chinese monosomic x C. 591 were back-crossed for the third time to 591. A complete set of crosses was made during this year between Chinese monosomes and Yaqui 58, a strain resistant to several races of black and brown rusts. Crosses were made between several induced speltoid, compactoid and awned mutants and some selected monosomes in order to identify the chromosomes involved in such mutations.

(c) Macromutations and sub-specific differentiation in *Triticum*

The inter-relationship among the hexaploid ($2n=42$) *Triticum* species, *T. aestivum* L., *T. sphaerococcum* Perc, *T. compactum* Host, *T. spelta* L., *T. macha* Dek. et Men. and *T. vavilovi* Jakub were studied in two ways. First a set of diallel crosses was made among these species and the F₁, F₂ and F₃ progenies were studied both cytologically and genetically. Secondly, all the species were treated with physical and chemical mutagens, and the mutations of phylogenetic interest occurring in the F₂ and subsequent generations were studied. The following indications have emerged from the study.

(i) *T. sphaerococcum* could not have arisen through a deletion from *T. aestivum* as suggested by some earlier workers since *aestivum* mutations readily occur in *sphaerococcum*. The *sphaerococcum* locus (s) which behaves as one unit in recombinations can be broken up by irradiation leading to the formation of phenotypes lacking the compact growth habit and rigidity of leaves but possessing hemispherical grains.

(ii) The gene controlling *vavilovoid* expression (i.e. elongation of rachillae) is also situated on the long arm of the chromosome 5A between the speltoid factor Q and the awn inhibitor B₁. *Vavilovoid* expression is suppressed by Q, as a result, a *vavilovoid* mutant can occur in *T. aestivum* only in conjunction with speltoidy.

(iii) *T. macha* has genes for both compactness of the spike and for speling. The compacting gene of *macha* seems to be homologous with the C gene of *compactum*. In view of the fact that the key characteristics of the 42 chromosome *Triticum* species are controlled only by one or two genes, all of them can be considered as sub-species of *T. aestivum* L. Macromutations, thus, appear to have played an important part in the differentiation of the hexaploid *Triticum* species.

(d) Interspecific hybridization in *Corchorus*

The F₃ progeny of the cross between *Corchorus olitorius* and *C. capsularis* reported last year as well as the F₂ progeny derived from another cross between the two species were studied during the current year. The segregation for all the characters differentiating the

two species was again found to be skewed in the direction of *olitorius*. Chromosome aberrations such as unpaired regions, and inversion loops at pachytene, a heteromorphic bivalent at metaphase I and a dicentric bridge and an acentric fragment at anaphase I, were recorded in seven F_2 plants. The cytological data, the occurrence of a high proportion of unthrifty and inviable seedlings and the skewed segregation behaviours observed in F_2 and F_3 progenies indicate that the genomes of *C. olitorius* and *C. capsularis* have differentiated in the duration of increased coherence which automatically decreases the possibility for effective recombination. From the breeding point of view, the occurrence of a number of trisomics in the hybrid progenies is a heartening feature, since a way is thus open for substituting whole pairs of chromosomes that cohere but do not recombine.

(e) The effect of oxygen in seed radiobiology

The role of oxygen in the mediation of radiation response in barley seeds was studied with reference to electromagnetic radiations (gamma rays) as well as beta radiations from ^{32}P , ^{35}S and ^3H (energy levels involved ranging from 0.018 Mev.). It was found that oxygen has no modifying effect on the action of densely ionizing radiations (e.g. Fast neutrons-800 ion pairs/ μ) while it has a profound modifying effect upto a factor of ≈ 10 with sparsely ionizing radiations (gamma rays-8 and 9 ions pairs/ μ). With beta radiations from H^3 (with 200 ion pairs/ μ), it is intermediate (a factor of 2.5 to 5) thereby indicating the possible relationships between ion density and oxygen effect.

C. PLANT PHYSIOLOGY

(i) Role of photosynthesis in grain development in wheat

The variety, Pbc. 281 raised under pot-culture was subjected to three intermittent drought treatments (i) commencing at dehiscence and continued throughout (continuous drought), (ii) only during the first fortnight after dehiscence (early drought) (iii), commencing a fortnight after dehiscence and continued upto maturity (late drought). The fourth treatment consisted of normal water supply. The main effect of early as well as late drought was reduction in grain weight (also its starch content) and 1000 grain weight. Under early drought, there also occurred greater reduction in stem-sugars (compared to normal water supply), without any appreciable increase in the rate of yellowing of ear, whereas under late drought only the yellowing of the ear was hastened. It would appear that the level of stem-sugars also influenced the grain filling process along with the green surface of the ear (i.e. photosynthesis). This observation lends an indirect support to the view that stem-sugars are utilised in starch accumulation in the grains.

It was reported earlier that the grain yield per ear of Pb.c.281 was consistently higher than that of N. P. 720, when these varieties were sown at the same time. Since the ears of Pb.c. 281 dehisced 3 to 4 days earlier than those of N.P. 720, it was likely that the ears of the latter might be exposed to a slightly higher temperature and grain development may thereby be adversely affected. The variety Pb.c. 281 was therefore sown a week later than N.P. 720 with the result that dehiscence occurred about 5 days later in Pbc. 281 and its grain developed at a slightly higher temperature. Under normal waters supply, the grain weight per ear was found to be equal in the two varieties, whereas under intermittent drought from dehiscence onwards the grain weight of Pb.c.281 was significantly higher than that of N.P. 720. Pbc. 281 had, moreover a slightly, but significantly higher starch content in grain than N. P. 720 under normal water supply and an appreciably higher starch content under drought. The ear of Pb.c. 281 yellowed at a slightly faster rate only during the last week of maturity. It would seem that the rate of yellowing of the ear of Pb.c. 281 was not particularly hastened and it photosynthesised equally actively, under a higher temperature and under deficient soil moisture and as such the ear of Pb.c. 281 might be regarded as relatively more resistant to atmospheric and soil drought from the functional point of view.

(ii) Mineral Nutrition

In a field experiment with the wheat variety N. P. 718 application of 2.3 lbs. of boron per acre increased the grain yield by 3 maunds per acre over control (0 lb. N yield 31.2 md). The increase in yield due to application of nitrogen (30 lb./acre), singly or in combination with P_2O_5 (40 lbs./acre) and K_2O (30 lbs./acre) was also of the same order. Boron application along with N or NPK did not increase the yield further as was reported earlier. There was an indication that the uptake of nitrogen by the plant was also increased due to boron application.

Zinc deficiencies in *bhindi* (variety Pusa Sawni) under water culture brought about an increase in ribonuclease activity and a decrease in the uptake of phosphorus much before the appearance of chlorotic symptoms in the leaves. This observation is in line with that on cotton reported earlier.

(iii) Analysis of tillering in wheat

Important differences between three varieties of wheat *viz.* N.P. 824, N.P. 826, and N.P. 828 observed earlier have been further analysed. Varietal differences in the tillering rate appeared from the time tillering commenced and the maximum tiller number was reached at approximately the same time in the three varieties. At the time the varietal differences in tillering appeared, the growing point was in the vegetative stage (about 3 to 4 weeks after sowing). Soon after, the growing point changed from the vegetative to the reproductive stage (elongation and differentiation of double ridges) and this change was noticed first in N. P. 828 and subsequently in N. P. 826 and N.P. 824 in that order. Within 3 to 4 days after this stage, the rate of development of the growing point was in the order N. P. 826, N.P. 820 and N.P. 824. Apparently the higher rate of tillering characteristic of N. P. 824 and N. P. 826 was not associated with delay in development.

The rate of uptake of N and K was more or less similar in the three varieties, but the phosphorus content (on fresh weight basis) was higher at least in N. P. 824 during the first 3 to 4 weeks. This raises the question whether phosphorus metabolism is in some way involved in the higher tillering of N. P. 824. Foliar spraying with sodium phosphate in the early stages significantly increased nitrogen uptake by the three varieties but the effect was much larger in N. P. 828; increase in phosphorus uptake was similarly large in N. P. 828 and the tiller number was significantly increased in this variety, while no such increase was obtained in N. P. 824 and N. P. 826. The ultimate maximum tiller number, however, varied as N. P. 824, N. P. 826 and N. P. 828.

The uptake of N and K by N.P. 824 after the peak tillering stage was less than that of N.P. 826 and N.P. 828, but foliar spraying with a mixture of urea and potassium sulphate did not increase the ear/tiller ratio of N. P. 824 to the level of N. P. 826 and N. P. 828; the ear number was, however, slightly increased in all the three varieties.

D. PLANT INTRODUCTION AND EXPLORATION ORGANISATION

(i) New Introductions

The Plant Introduction and Exploration Organization introduced during the year 3299 samples of seeds and other planting materials from foreign countries and collected 728 samples of wild and cultivated plants from within the country. The new introductions included 217 genetic stocks of barley from East Germany, 519 of wheat from U.S.A., 243 varieties of groundnut and 148 of *Sesamum* from Sudan and 243 strains of chilli and wheats. Thirty two exotics comprising mostly tetraploid rye, clovers, *Poa* species, timothy and wheats were specially introduced for trial in the high altitude regions of the country. Other economic species included a Mexican wax yielding plant *Euphorbia antisyphilitica*, an oil yielding tree, *Simarouba glauca* from Central American, and Brazil nut (*Bertholletia excelsa*) from Malaya. Introduced plants which are close relatives of economic species

included *Allium chinense* and species of *Hordeum*, *Triticum*, *Phaseolus*, *Fagopyrum*, *Oryza* and *Vigna*. Varieties of sarda type musk-melon from Afganistan and of water-melon from U. S. S. R., of lico rice from Iraq, were also introduced. The introduced horticultural materials comprised species of *Mangifera* from Malaya, Citrus varieties from U. S. A., varieties of fig from Israel, and essential oil-yielding *Rosa* species from Bulgaria. Accession of forage grasses and legumes included species of *Andropogon*, *Paspalum*, *Oryzopsis*, *Sorghastrum*, *Calopogonium*, *Desmodium*, *Desmathus*, and a Japanese variety of Russian Comfrey. An extensive collection of guar (cluster beans) was made from the guar growing regions of Rajasthan.

(ii) Exploration

Plant Exploration work was carried out in Central Nepal from where 700 samples of seeds and other planting materials were collected. Besides the agricultural crops viz., barley, rice, maize, *ragi*, soybean, amaranth, buck wheat, and vegetables such as tomato, beans, cucuribits and chillies, the collection made comprised wild species of *vitis*, *Dioscorea*, *Rubus*, *Buddleia*, *Deutzia*, and other ornamentals as also wild species of *Abelmoschus*, *Solanum*, *Trichosanthes* and *Cucumis*.

(iii) Evaluation

The work on evaluation, maintenance and utilization of exotic and indigenous collections was continued as an essential part of the introduction programme. The Australian milling cat variety 'Kent' was finally selected for release to the farmers. The grains of this variety which are bold and show a low hull percentage (33.24) are very suitable for the breakfast food industry; its cultivation can be expected to be gainful to the farmer and at the same time save foreign exchange now required for import of grain of the desired milling quality. The south American grain chenpods viz., *Chenopodium quinoa* and *C. nuttaliae*, were compared with the indigenous *C. album*. The average per plant yield in *C. quinoa*, *C. nuttaliae* and *C. album* was 18.5, 14.3 and 4.3 grams respectively. The corresponding figures for 1,000 grain weight were 3.5, 2.0 and 1.8 grams respectively. Another important desirable character of *C. quinoa* is the attractive white colour of the grain. *C. quinoa* and *C. nuttaliae* are being further tested in the hill areas. It was also observed that *C. nuttaliae* could be profitably used as a winter leafy vegetable in the plains in preference to the local *bathua*. A very late fruiting variety of cowpea (E. C. 18217) produced a vigorous growth and very proliferous clusters of large thick pods. Among the collection of *Dolichos lablab*, the accessions E.C. 18129 and E.C. 18130 were considered important stocks, the former for its bushy habit earliness and bitter free pods and the latter for large size roundish pods. Cowpea varieties collected in 1960 from Kinnaur district of Himachal Pradesh were characterised by upright bushy habit, extreme earliness and short life cycle. The *bhindi* collection no. I. C. 7194 from a Punjab village was observed to be remarkably free from jassids under field cultivation and was considered a valuable breeding stock.

Trials were undertaken on a collection of various fodder root plants such as swedes, turnips, and beets. A variety of fodder beat from France was found to be promising by virtue of its freedom from pests and diseases, capacity to withstand heat, and show good root-development. Fodder turnips however were the earliest in root development. Amongst the fodder roots 'Kent' topped the list, in giving high forage yield; this variety was also conspicuous by its stiff straw. The variety 'Overland' from the U.S.A. was observed to be more suitable for late sowing to grow the *kharsai* or the late crop available during summer. At the Simla substation, Russian comfrey (*Symphyticum perigrinum*) has given encouraging result as a perennial forage plant for the hill conditions. Experiments were in progress to determine the best practices for harvesting the green fodder of this species. A species of *Desmodium*, namely *paleaceum* from Nigeria, which was earlier reported to be a valuable species on account of its succulence, summer growth

and winter hardiness could not be utilized in the absence of flowering and fruiting. Experiments on its vegetative propagation have shown that ground layering is very successful and to some extent cuttings also take root. It is now proposed to carry out further tests with this legume.

E. FUNDAMENTAL PLANT GENETICAL RESEARCH LABORATORY

(a) Work on genetic determination of quantitative variation

A hypothesis based primarily on cytogenetical rather than biometrical considerations, was being developed in relation to the inheritance of quantitative characters. It has been concluded on the basis of several general considerations relating to the nature of quantitative characters and in view of evidence concerning the nature and organisation of genetic material, and biochemical understanding of generation, that both quantitative and qualitative variation can be interpreted with the genes of the same class acting in conjunction with the genetic background and the environmental tractors. From a plant breeder's point of view, the hypothesis has important implications for it has brought out some serious limitations of the existing methods of analysis, and has suggested several new lines for further work in the field.

(b) Correlated studies on heterosis and genetic homeostasis

The concept of genetic homeostasis has led to the suggestion that the greater developmental stability of the hybrids may be an important factor in determining hybrid vigour. An experiment was planned in maize to test this idea. A number of maize hybrids which show varying degree of heterosis are being studied for their developmental stability for various cytological and morphological characters.

(c) Cytogenetical studies in the genus *Sorghum*

The innumerable varieties and forms met with in the genus *Sorghum* constitute a wealth of still unexplored variation. There has been considerable disagreement as to the classification to be adopted and the taxonomic status to be accorded to these different forms, as also regarding the evolutionary relationship between them. Detailed cytogenetical studies of the different *Sorghum* species and species hybrids were undertaken, since such knowledge can be expected to aid considerably in the better understanding of the genetics, taxonomy, and phylogenetic evolution of the various forms in this genus. Karyomorphology of twenty two species was studied both at somatic metaphase in root tip cells and at pachytene in pollen mother cells. Ten pachytene bivalents have been identified for the first time in all these species. The pachytene idiograms of all the ten bivalents in each of these species were also compared with the idiograms of the somatic chromosomes. Many so-called species are being lumped into certain groups on the basis of these results. The existence of cytological differences between the two sub-sections, *Arundinaceae* ($2n=20$) and *Halepensis* ($2n=20$) of *Eu-Sorghums* has also been revealed from these studies.

About 104 species hybrids at various ploidy level, not reported before, were successfully made employing suitable techniques. The nature of chromosome pairing especially at pachytene level, was analysed in about sixty of the hybrids at $2n=20$ level. In addition to normal pairing in some of the hybrids, deviations from the normal synapsis of chromosomes, such as the presence of duplications, differential terminal segments, terminal deletions, inversions, non-pairing regions etc. were encountered in certain other hybrids. The conclusion "that interspecific hybrids in *Eu-Sorghums* are not qualitatively or quantitatively different from those in corresponding parents" arrived at by the early workers, has been shown by the present studies to be incorrect and unjustified.

Critical cytological studies were also made in some polyploid species and their hybrids laying emphasis on the nature of chromosome pairing with a view to obtain a clear understanding of the genome relationship and nature of ploidy in them.

It has now become possible on the basis of these results to formulate various cytogenetical mechanisms underlying species differentiation in the genus *Sorghum*. The information will be of value in planning breeding experiments on this crop.

F. SEED TESTING

In addition to seeds of vegetable crops, over 300 samples of wheat and paddy seeds sent by the Seed Multiplication Officers belonging to the districts covered by the Intensive Agricultural Programme were subjected to purity and germination tests. Though the seeds in general were satisfactory from the view point of purity, many samples showed poor germination, thus suggesting that the conditions under which they were stored were not ideal. Seeds of sixteen plant species were studied by the X-ray contrast method developed in Sweden, by Drs. A. Gustafsson and M. Simak. This method is based on the principle that different parts of a seed such as testa, endosperm and embryo absorb X-rays to different extents and can consequently be differentiated in X-ray photographs. The studies showed that this technique can be used to assess reliably the germination potentiality of seed samples. Inadequate development of the embryo and endosperm, mechanical injuries as well as infestation with pests can all be readily detected and quantitative estimates made.

Seed Production and Supply

(i) **Wheat.**—The Division continued to coordinate the work relating to the distribution of seeds of 'New Pusa' wheat varieties produced in the Institute's fields at Delhi, at A. R. S. Karnal and B.S.S. Pusa and at two of the Wheat Breeding Substations—Simla and Indore. It was not possible to meet the total requirement of all the indentors in view of the limited facilities available at the Institute for seed multiplication work; 61885 Kgms. of seeds could be supplied as against a demand of 267230 Kgms.

(ii) **Other Crops.**—There was also considerable demand for seed of various other crops and the amounts indicated below were supplied.

Crop	Quantity (Kgms.)
Barley	1,249.599
Maize	4,514.916
Paddy	5,170.000
Gram	249.061
Oats	878.464
Mung	267.066
Cowpea	683.000
Bajra	17.500
Jute	102.527
Linseed	63.662
Lentil	49.130
TOTAL	13,245.525

Botanical Substation, Pusa

The work of the station was planned mainly for the maintenance, multiplication and testing of improved varieties and other materials which were expected to be of potential value in breeding programmes. The important crop plants which received attention included wheat, rice, gram, oats, linseed, pulses including *urid* and *arhar* and fibre plants including jute and *Hibiscus*.

In a breeding programme on wheat, 25 crosses were attempted with the object of incorporating rust resistance, high yielding potentiality and grain quality in the standard varieties N.P. 761, N.P. 798, N.P. 823, N.P. 824 and N.P. 835 using E. 871, E. 1913 and E. 2842 as donors of rust resistance. Also a study of 10751 selections from 96 crosses in the various generations, was made and 72 bulks and 2645 single plants were selected on the basis of rust resistance. Only 39 bulks and 453 single plant selections were finally retained after thorough screening on the basis of grain quality and rust resistance.

Yield trials with seven varieties of N.P. wheats of 800-series were continued for the third consecutive year throughout the eastern zone using as controls N.P. 710, N.P. 718, N.P. 758, N.P. 761 and N.P. 798. The results of these yield trials confirmed the superiority of N.P. 824 and N.P. 835; the latter being observed to be resistant to all the three rusts under natural conditions of rusts.

PROGRAMME OF WORK FOR 1962

1. Improvement of Indian wheats with special reference to breeding varieties for different agronomical conditions.
2. Genetics of rust resistance and other characters in wheat.
3. Study of the suitability of N. P. Wheats and other breeding material to different agronomical conditions.
4. Study of the milling-baking and *chapati*-making qualities of Indian wheats.
5. Breeding for rust and smut resistance in barley.
6. Breeding for rust resistance and earliness in linseed and wilt resistance and earliness in pigeon-pea (*Arhar*).
7. Breeding extra-long staple varieties of cotton.
8. Trials with the recently evolved N. P. strains of crop plants in the different states of India.
9. Trials with foreign varieties, foreign and indigenous inbreds and hybrids of maize on a regional basis in India.
10. Investigations on the utilization of hybrid vigour in various crop plants including maize, *jowar*, *bajra*, *onion*, *bhindi*, radish, tomato, brinjal and cotton.
11. Breeding for high yield and early ripening in fodder and grain types of *jowar* and *bajra*.
12. Breeding of some pasture grasses and legumes for northern India, with special reference to suitability to arid, semi-arid and hill regions.
13. Study of the wild relatives of crop plants and their utilization in plant breeding.

14. Improvement of chilli, with special reference to the breeding of disease resistant varieties.

15. Improvement of some essential oil bearing plants, *e.g.*, cumin, dill, fennel, coriander and carum.

16. Breeding of vegetables, including the European type vegetables such as cabbage, cauliflower, turnip etc. and development of improved methods for the commercial production of quality seed in them.

17. Testing and certification of seeds of vegetable crops.

18. Improvement of ornamental plants by the application of modern techniques like induction of polyploidy and mutations.

19. Studies on Improvement of Pulses.

20. Induction and study of polyploidy as a method of crop improvement in Oleiferous *Brassica*, linseed, barseem etc.

21. Cytogenetical studies in various crop plants, including cotton, oilseeds and millets.

22. Monosomic analysis of rust resistance and other characters in wheat.

23. Cyto-taxonomical and cyto-ecological studies in some Indian fodder grasses.

24. Induction of mutations in crop plants through the use of chemicals and radiations from radio-active isotopes, neutrons, X-rays and Ultra-violet rays.

25. Studies on the incidence and induction of pollen sterility in crop plants.

26. Application of embryo culture technique to overcome embryo lethality in distant crosses.

27. Improvement of cytological techniques.

28. Radiobiological studies on seeds.

29. Studies on temperature sensitivity of chromosomes in wheat and other plants.

30. Differential mutability of genes with various mutagenic agents.

31. Fundamental and applied studies on distant hybridisation in economic plants.

32. Cytogenetical studies in barley and other plants with reference to control of intranuclear control of recombination.

33. Studies on genetic control of self-incompatibility in plants.

34. Physiological studies on resistance to drought and lodging.

35. Physiological analysis of factors concerned with yield in wheat.

36. Influence of light and temperature on growth and development in wheat.

37. Physiological aspects of plant nutrition in wheat—studies on the relation between varietal differences in the uptake of nutrients.

38. Plant hormones—investigations on their role in growth and development in wheat, cotton, etc. and their use as weedicides.

39. Plant Physiological studies in relation to the die-back disease of citrus.

40. Studies on genetic determination of quantitative variation.

41. Multiplication and distribution of the pure seeds of improved N.P. varieties of field and vegetable crops.

42. Inheritance studies on chemical differences determining quality characters in economic plants.

DIVISION OF HORTICULTURE

(Dr. S. K. Mukherjee)

RESEARCH

I. Fruit Section

(1) *Mango* :

(a) *Collection*.—Grafts of nine varieties of mango, were obtained from West Bengal for study of their performance under Delhi conditions. Besides, budwoods of three polyembryonic varieties, namely *Kurukkan*, *Peach* (Florida) and *Terpentine* were collected from Saharanpur and grafts were raised. A Malayan species *Mangifera caesia* was introduced through the Plant Introduction Organisation.

(b) *Taxonomic studies*.—Detailed descriptions of thirty eight varieties grown in Delhi and at Saharanpur have been made. The disc lobes, position of ovary, colour of anthers, and shape of petals show variations. A formula based on the length, breadth and thickness of fruit, which gives an approximate estimate of fruit size, has been worked out.

(c) *Performance studies*.—Yield and other records of 23 varieties, 8-9 years old, grown under Delhi conditions, have been maintained. It is interesting to note that the performance of Neelum, a South Indian commercial variety, is good under North Indian conditions also. It has produced 245 fruits whereas *Safeda Malihabad* has produced 433 fruits, and *Lucknow Safeda*, 306 fruits.

(d) *Propagation*.—Studies were undertaken to compare the 'take' and performance of grafts raised by veneer grafting and budding. The data on the success obtained by the two methods, during different months, are given in the following table:

Variety	July			September			October		
	Number grafted	Number sprouted	%age	Number grafted	Number sprouted	%age	Number grafted	Number sprouted	%age
V. grafting . .	25	20	80	25	23	92	25	12	48
Langra budding .	25	3	12	25	1	4	25	..	..
V. grafting . .	25	20	80	25	5	20	25	..	..
Dashehari budding .	25	5	20	25	..	..	25	..	..
V. grafting . .	25	19	76	25	11	44	24	12	50
Chousa budding .	25	5	20	25	..	..	25	..	..

N.B.—Due to heavy rains in August, propagation operations could not be done.

In the following table the average extension growth of scion and the average number of branches, it produced in July raised grafts, are compared.

Variety	Veneer grafting		Budding		Inarching	
	Scion growth in cm.	Number of branches	Scion growth in cm.	Number of branches	Scion growth in cm.	Number of branches
Langra	18.7	1.5	9.6*	1	18.9	1.4
Dashehari	17.7	1.2	..	..	16.3	1.4

*The data include the average of three varieties.

These data show that veneer grafting may replace the hitherto-widely-used method of inarching. The former method has an added advantage (*i.e.*) larger number of grafts can be raised from a tree because it is a method of grafting with detached scion.

(e) *Biennial bearing*.—An experiment was designed to determine whether the age of the leaves has any relation in transmitting the stimulus to flowering. In the variety *Neelum* flowering was noted even in the October flush of growth. It seems, therefore, that the young as well as old leaves in the *Neelum* variety are involved in the production of flowers. These preliminary observations can be of help in studying the shoot growth flowering relationship, which governs the biennial or regular bearing habit.

(f) *Blossom biology*.—The number of hermaphrodite flowers in different varieties of mango was determined. It was less than one per cent in the varieties *Suvarnarekha*, *Allumpur Baneshan* and *Baneshan*. It is noteworthy that in *Dashehari* variety the panicles inside the tree contain twice the number of hermaphrodite flowers than the panicles on the periphery of the tree. Late flushes have more than three times hermaphrodite flowers than those in the early flushes. Preliminary observations have indicated that maleic hydrazide (200 and 400 ppm) and naphthaleneacetic acid (100, 200 and 400 ppm) sprays help in increasing the production of hermaphrodite flowers in var. *Janardhan Pasand*.

It was noted in the variety *Dashehari* that selfed fruits did not develop beyond pea stage while fruits developing from open pollination showed higher rate of fruit development.

(g) *Hybridisation*.—A large number of crosses were made with different varietal combinations. All the surviving seedlings have been planted in the field. The details of the crosses are given below.

Parents	No. of panicles	Number of flowers crossed	Number of fruits set pea stage	Number of fruits harvested	Number of seedlings obtained
Dashehari × <i>Neelum</i>	92	925	586	32	29
Dashehari × Totapari (Red small)	113	1,435	551	29	29
<i>Neelum</i> × Langra	32	212	92	10	8
<i>Neelum</i> × Dashehari	48	425	134	12	10
Chowsa × <i>Neelum</i>	19	77	23	—	—
Langra × <i>Neelum</i>	46	513	184	..	..
Langra × Totapari (Red small)	7	77	4	..	..
Totapari × Dashehari	29	240	8	..	—

(h) *Fruit drop*.—Studies in two varieties, Dashehari and Langra, showed that a high percentage of dropped fruits, contained shrivelled and degenerated ovules in the mustard and pea stages of fruit development. Ether extracts of seeds of adhering and abscising Dashehari fruits showed significant difference in abscission test on debladed coleus petioles, whereas in Langra, difference was not significant. A highly significant and negative correlation was observed between fruit retention and percentage of shoots putting forth new growth on individual branches in the young trees of the varieties. While weekly irrigation failed to arrest the drop appreciably, girdling was more effective in reducing the drop. Plant regulator spray mixtures GA (5 ppm) + NAA (40 ppm) gave promising results in reducing fruit drop in both the varieties.

(2) *Citrus* :

(a) *Taxonomic studies*.—Detailed study of 28 *Citrus* varieties, comprising 13 species mostly indigenous to Assam, was made. It was observed that rough lemon and *Mitha-kagzi* possessed distinct characters and within each group considerable range of variation was noted. Both of these occur in semi-wild conditions in Assam. The botanical names *C. jambhiri* (Lushington) and *C. limettoides* (Tanaka) of these respectively were found to be valid and acceptable. All the varieties of mandarins studied, deserved to be grouped under *C. reticulata* (Blanco). All the lemon varieties (Soh-synteng, Elachilebu, Patilebu, Soh-long and Assam lemon) were found to have admixture of characters of lemon and citron. Janeru-tenga, of Assam was found to be akin to the King Orange, *C. nobilis* (Lourieoro).

(b) *Propagation studies*.—A mixture of soil and peat moss in equal proportions proved to be a suitable medium for *Karna Khatta* hardwood cuttings. Vermiculite, however, gave highest percentage of survival after replanting. With regard to Sweetlime, mixture of IAA and IBA at concentrations of 2500, 2000 and 1500 ppm (quick dip) was found to accelerate the rooting.

Very high percentages of polyembryony were observed in mandarins (98-100 per cent), sweet orange (98 per cent), Karna Khatta (97 per cent), Jamberi (96 per cent and calamondin (93 per cent). Mandarin and calamondin showed maximum range in the number of embryos (1 to 10 and 1 to 11 respectively) and the average was 4.08 to 4.41 and 4.01 respectively. Spray application of GA, kinetin and 2, 4-D to fertilised ovaries of citrus fruits at very low concentrations failed to alter the percentage of polyembryony in *Citrus*.

(c) *Growth studies*.—(i) In sweet orange (*C. sinensis*) variety, *Hamlin*, five distinct flushes of vegetative growth were noted and July flush was found to be more productive. A strong tendency of alternate bearing was observed in individual shoots carrying fruits to maturity. There is a positive correlation between the number of flowers to leaf area and extension growth and number of leaves. Investigations on seasonal changes in chemical composition of shoots, carrying to maturity in Hamlin and Valencia, showed that the total dry matter content of all the flushes during early spring was highest in comparison to other sampling dates. Starch concentration was minimum during winter and maximum in early spring in twigs. The total soluble carbohydrates content in twigs of different flushes was highest in early spring. It was noted that nitrogen, phosphorus and potassium content was maximum in young twigs which decreased with increasing age of twigs. The C/N ratio was low in young leaves and highest in October flush. High (but not very high) nitrogen accompanied by moderate quantity of phosphorus, potassium, calcium and starch, was favourable for flowering and fruit set.

Analysis of fruits at different periods, has shown that Hamlin may be harvested in first week of November and Valencia Late by the last week of January. (ii) In the mandarin (*C. reticulata*) varieties Kaula and Nagpuri, five distinct flushes of growth were observed. Kaula was found to be more vigorous in extension growth than the Nagpuri. Observations on the behaviour of fruiting and non-fruiting in Nagpuri variety revealed that individual shoots had a tendency towards alternate bearing. Active period of blossom bud differentiation was found to extend over a fortnight from the last week of January. The terminal buds differentiated more in number than the lateral ones. The highest concentration of ascorbic acid in fruit juice was found during the month of October and November and was followed by a gradual decrease thereafter. (iii) In the grapefruit (*C. paradisi*) varieties, Marsh Seedless and Pink, four distinct flushes were noted. March and July flushes were found to be more productive. The number of flowering shoots was higher in terminal shoots. The individual shoots of Marsh Seedless showed a strong tendency of alternate bearing and this was found to be less pronounced in Pink variety. Chemical analysis of shoots showed that total dry matter content was high up to the end of November and decreased afterwards in both the varieties. Shoots of Pink variety and higher content of carbohydrate and inorganic constituents than the other variety. The fruits of these varieties should be harvested by the middle of December after which deterioration of fruit quality sets in. (iv) Similar studies in sweet lime (*C. limettioides*) showed that it has four distinct flushes. July flush produced maximum percentage of productive shoots followed by spring flush. Flowering shoots were found to cease growing earlier than the non-flowering ones and the former exhibited a marked tendency of alternate bearing. Younger shoots were found to contain higher amounts of nitrogen, phosphorous, potassium and magnesium while calcium content was higher in older shoots. Potassium was more in flowering than in vegetative shoots.

(d) *Fruit set and fruit drop*.—In the two mandarin (*C. reticulata*) varieties studied, it was noted that pollen fertility was much higher in Nagpuri (83.23 per cent) compared to Lahore Local (59.87 per cent). Maximum pollen germination was observed in 20 per cent sucrose solution. In natural selfing, maximum fruit-set of 78 and 75 per cent respectively was recorded in the two varieties. In the variety Nagpuri, application of GA (300 and 600 ppm) and ClPA (75 ppm) proved effective in increasing the fruit-set. Ringing and girdling failed to increase the fruit-set in both the varieties.

The distinct waves of fruit drop were noted. The seed extract of the picked fruits, delayed coleus petiole abscission considerably as compared to the extract from dropped fruits. Low activity of seed extract obtained from dropped fruits is possibly due to low seed content.

In Nagpuri variety, application of 2, 4-D (20 ppm) and 2, 4, 5-T (10 ppm) in lanolin reduced the June drop while aqueous sprays of 2, 4, 5-T (5 ppm) were effective in reducing total drop. In Lahore Local, aqueous sprays of 2, 4-D (15 and 20 ppm) and 2, 4, 5-T (10 ppm) significantly reduced the total drop. Abscission tests carried out *in vitro*, in both the varieties, revealed that 2, 4-D and 2, 4, 5-T from 1 to 20 ppm., delayed abscission. Kinetin and mixture of GA with Kinetin, slightly accelerated the rate of abscission.

(3) *Grape* :

(a) *Collection*.—Further intruductions have been made from California and Florida which includes two species of *Vitis* viz. *Vitis rupestris* and *Vitis Champini* also. The progressive total of the varieties now under study is 174.

(b) *Varietal Performance*.—Records regarding the flowering of ten promising varieties are given below.

Name of the variety	Number of bunches per vine	Average bunches wt. in grams.	Average yield per vine in Kg.	Total soluble solids %	Season of harvest
Alamwick	16	240	3.83	16.6	Middle of June.
Bharat Early	22	106	2.77	22.0	Fourth week of June.
Bhokri	22	143	3.14	16.7	First week of June.
Black Hamburg	34	109	3.70	17.0	First week of July.
Black Muscat	19	92	1.75	16.5	Second week of June.
Fakhri	9	366	3.41	14.0	First week of July.
Gros Colman	16	390	6.25	18.5	First week of July.
Hur	12	250	3.00	16.6	Second week of June.
Kandhari	5	300	1.50	17.0	Second week of June.
Tas	18	410	7.38	14.0	Second week of July.

It is seen from the above data that Gros Colman yields fairly well but slightly late. Bharat Early, even though a poor yielder, produces the sweetest berries in the collection. The early varieties which mature well before the monsoon are Bhokri, Kandhari, Alamwick and Black Muscat. Among the other varieties, which came into bearing for the first time are Catawba, Haitha seedling, Convent Large Black, Muzzaffarnagar No. 1, Muscat White and Pearl of Csaba. The berries of the first two of these recorded total soluble solids of 18 per cent.

(c) *Hybridisation and colchiploidy*.—Crosses have been made between Pusa Seedless Gros Colman and Bhokri. Production of a seedless variety is being attempted and as a first step suspected tetraploids were being screened out in the varieties Bhokri, Bharat Early, and Kandhari.

(d) *Pollination studies*.—Artificial induction of pollen sterility was attempted in some varieties of grapes. Maleic hydrazide, TIBA, and FW 450 were sprayed to the foliage of selected shoots in the varieties of Bhokri and Gros Colman. Preliminary observations reveal complete sterility of pollen and no fruit-set in the bagged shoots. In order to test whether these chemicals affect ovular fertility, controlled pollinations were made with good pollen of untreated shoots. It was noted that ovular fertility was not affected and fruit-set was observed.

(4) *Papaya (Carica papaya)* :

(a) *Hybridisation*.—A number of crosses in Barwani variety, have been made between female and male, female and hermaphrodite and hermaphrodite plants (10 stamens and 5 stamens) were also selfed. The seedlings are under observation.

(b) *Irradiation studies*.—Seeds and seedlings of Barwani variety were irradiated with varying doses of gamma rays ranging from 1000 r to 10,000 r. Except mottling, no other phenotypic changes were observed in the treated seedlings. The pollen fertility was not affected. Observations would be continued in succeeding generation also.

In the 10,000 r series, one plant was found to produce typical female flowers on pendulous peduncle, which is characteristic of male inflorescences in normal plants. Similarly, in 5000 r series, male flowers are borne with sessile and axillary peduncles, which character was unlike the typical male.

(c) *Sex determination*.—Colorimetric tests of undifferentiated papaya seedlings were made for their sex determination. Leaf extracts of seedlings were treated with remodified Almen reagent. The colour reactions were found to fall in two main groups. The undifferentiated seedlings under these groups were later compared with field observations when the seedlings came to flower. The sex forecast, according to the colour grouping, agreed to the extent of 67 per cent and 87 per cent in the case of male and female plants respectively.

(5) *Guava (Psidium guajava)*:

(a) *Propagation studies*.—T-budding with Lucknow-49 in the months of March, April, May and June, gave the highest budtake of 60 per cent in April. In similar experiments with Safeda and Chittidar varieties, it was noted previously that the months of March and April respectively were found to be the optimum period.

(b) *Varietal performance and floral biology*.—Among the six varieties under trial, Lucknow-49 seemed to be the good cropper under Delhi conditions. The small fruit-size and extremely low fruit-set in the variety Seedless are the unfavourable factors in Seedless variety. Chittidar, Safeda Red fleshed are the other varieties in order of merit next to Lucknow-49. As regards flowering, all the varieties have two flowering periods and Apple Guava and Seedless were the last to come to flower with the shortest flowering period. The fertility of pollen was low (43.15 to 45.13 per cent) in Seedless while it ranged from 84 to 96.4 per cent in other varieties. The guava pollen tended to lose its stainability within 24 hours under natural conditions. The pollen grains of Seedless variety did not germinate even in 25 per cent sucrose solution while in other varieties, germination was obtained with 10 to 15 per cent sucrose. Fruit drop was found to be quite high in all the varieties.

(6) *Loquat (Eriobotrya Japonica)* :

(a) *Taxonomical studies*.—Nine varieties viz; California Advance, Fire Ball, Golden Yellow, Improved Golden Yellow, Large Agra, Large Round, Pale Yellow, Tanaka and Thames Pride were studied and described in detail. A tentative key for identification of these varieties was formulated on the basis of variation in leaf margin, leaf base and fruit characters.

(b) *Pollination studies*.—Four types of pollination namely, natural open pollination, natural self pollination, hand self pollination and hand cross pollination were studied. The data in respect of first two modes of pollination are given in the following table.

Variety	Percentage of fruit-set	
	Natural self pollination	Natural cross pollination
California Advance	16.4	66.0
Fire ball	13.7	44.00
Golden Yellow	1.6	51.5
Improved Golden Yellow	..	53.8
Large Agra	5.0	68.5
Large Round	5.3	74.7
Pale Yellow	1.4	52.4
Tanaka	24.6	75.0
Thames Pride	14.4	48.0

Complete self-incompatibility is evident in the variety Improved Golden Yellow while in other varieties it occurs in varying degrees.

Controlled cross pollination was done using different combinations and the percentage of fruit-set recorded is presented in the accompanying table.

	Califor- nia Ad- vance	Fire Ball	Golden Yellow	Impro- ved Gol- den Yellow	Large Agra	Large Round	Pale Yellow	Tanaka	Thames Pride
Improved Golden Yellow	56.0	43.3	25.0	..	46.4	45.0	43.3	50.0	41.6
Pale Yellow	50.0	41.6	40.0	45.0	53.3	45.0	..	46.6	43.3

It is evident that California Advance can be used as the best pollinizer for the two varieties Improved Golden Yellow and Pale Yellow.

(7) *Phalsa (Grewia asiatica)* :

Blossom biology.—The pollen grains were found to be quite large (61.25 microns). The pollen fertility was found to be 71.77 per cent and the natural fruit set under cross pollination was 61 per cent.

(8) *Peach (Prunus persica)* :

Floral biology.—Seven peach varieties, viz., Double flower, Florida's Own, Gujerati, Large Agra, Unknown, Hakim and Waldo were studied. Florida's Own and Hakim varieties did not produce viable pollen and were self-sterile. All the varieties were found to be diploids with $2n=16$.

(9) *Plum (Prunus sp.)* :

Morphological studies of 13 plum varieties were made and eight varieties showed vigorous growth under Delhi conditions. Flowering was found to be earlier than the normal period under temperate conditions. All the varieties except Alucha Black proved self sterile. Alucha Black variety gave 32.02 per cent fruit-set on selfing. No cross-incompatible combinations were observed. Among the good pollinizers, that can be recommended, are Alpha and Alucha Black. From leaf tip squashes, the somatic chromosome number was determined as $2n=16$. Eight bivalents were observed in pollen mother cells.

(10) *Small fruits.*—Collection has been built up in strawberry, making introductions from Nainital, Almora, Simla and Kulu Valley. Besides, seedling of *Fragaria moschata* have been raised from the seeds received from California. A variety of cape gooseberry (*Physalis peruviana*) called Tomatillo, has been obtained from Andhra Pradesh.

II. Vegetable Section :

(1) *Tomato* :

(a) A selection (No. 120), found to be highly resistant to rootknot nematode as reported last year, was again tested under field conditions for resistance. Laboratory tests at Mycology Division have also confirmed these findings. This selection is recommended for growing in areas infested with nematodes.

(b) *Genetical studies.*—In a study on the inheritance of characters, it was concluded that two factors (R and T) determined the fruit skin colour. The deep red flesh colour of fruit was dominant to pinkish red colour. The green stem end colour in the mature fruit

was dominant over uniform colour (red or pink) and governed by two complementary factors Ur and Ug . Non-cracking character of the fruit base, was found to be dominant over distinct cracking of the fruit in F_1 and a dihybrid ratio of 15:1 was obtained in F_2 . As regards the number of locules per fruit in F_3 , a monohybrid ratio of 3 few loculed: 1 many loculed, was obtained. Erect habit of plant was dominant over spreading habit. Linkage existed between genes for fruit skin colour and fruit flesh colour.

(c) *Physiological studies*.—Application of plant regulators in increasing the yield of tomato, was studied. The results are given in the following table.

Yield in kilograms per acre

Treatment				Methods of Application				
				Seed treatment S_1	Seedling treatment S_2	Whole plant spray S_3	Flower cluster spray S_4	Mean
T_1	2,4-D	1 ppm	.	15,842.08	11,012.17	20,344.13	11,597.62	14,699.0
T_2	2,4-D	5 ppm	.	16,831.47	9,806.16	12,183.06	16,609.01	13,857.4
T_3	2,4-D	10 ppm	.	14,893.65	6,949.20	6,949.20	11,515.66	10,076.9
T_4	CIPA	10 ppm	.	13,904.26	12,294.29	19,243.50	16,831.47	15,568.4
T_5	CIPA	25 ppm	.	16,901.73	9,437.33	14,747.30	12,622.14	13,427.1
T_6	CIPA	50 ppm	.	10,719.25	9,583.69	6,949.20	12,364.55	9,904.2
T_7	GIB	10 ppm	.	11,088.28	10,754.58	15,438.12	13,172.46	12,613.4
T_8	GIB	25 ppm	.	13,535.43	10,842.40	14,999.04	14,161.86	13,384.7
T_9	GIB	50 ppm	.	15,186.38	7,382.43	12,475.78	12,071.83	11,779.1
T_{10}	NoA	50 ppm	.	11,234.64	10,977.05	13,283.69	12,147.93	11,910.8
T_{11}	NoA	100 ppm	.	12,990.97	11,515.66	16,838.79	15,918.18	14,315.9
T_{12}	NoA	150 ppm	.	13,137.33	6,802.84	13,500.31	13,997.93	11,859.6
T_{13}	Water only	.	.	11,012.17	11,597.62	11,269.77	13,242.71	11,780.6
T_{14}	Control	.	.	9,899.83	12,539.43	11,911.86	11,416.13	11,941.6
Mean				13,369.83	10,177.92	13,652.62	13,404.96	12,651.33

C.D. at 5% for S. 1,024.52

C.D. at 5% for T. 1,457.75

S. at the same level T. 2,975.80

T. at the same level S. 2,915.50

Seed treatments with gibberellin resulted in very tall plants. All treatments were better than the control in producing greater number of branches. 2,4-D, GIB, NoA treatments recorded better spread of the plants than the control. Seed treatment, whole plant spray and flower cluster spray were found superior to the seedling treatment. 2,4-D at 1 and 5 ppm, CIPA at 10 and 25 ppm GIB at 25 and 50 ppm, and NoA at 100 and 150 ppm, significantly increased the yield. Plant tissue analysis showed that the uptake of nitrogen was significantly higher in seed treatment in T_1 to T_6 and that of phosphorus was higher in T_4 , T_5 , T_6 , T_7 , T_8 and T_9 than the control. There was no effect on the uptake of potash.

(2) *Brinjal (Solanum melongena)* :

Hybridization.—Crosses between Pusa Purple Round (Late varieties bearing few round fruits) and Pusa Purple Long (Early variety bearing many thin and long fruits) were under study. Some lines have now been selected in the F_4 generation which are early and bear larger number of medium sized round fruits and which bear medium type long fruits.

(3) *Bottle gourd (Lagenaria siceraria)* :

Hybrid vigour.—Six parents, comprising three long and three round types were used for study of the manifestation of hybrid vigour. General combining ability with regard to yield was worked out.

Pedigree	Mean harvest in grams	Parental average in grams	Superior parent in grams	Increase or decrease	
				Parental mean	Better parent
Parents :					
No. 2 (long) . .	4,191.5	..	..	..	..
No. 4 (Long) . .	3,460.6	..	..	..	..
No. 6 (Long) . .	3,359.2	..	..	..	..
No. 7 (Round) . .	6,952.6	..	..	..	..
No. 9 (Round) . .	3,961.3	..	..	..	..
No. 11 (Round) . .	3,618.8	..	..	..	..
Crosses :					
2×7	7,062.5	5,572.05	6,952.6	26.75	1.58
7×2	4,441.7	5,572.05	6,952.6	—20.29	—36.11
2×9	6,050.0	4,076.40	4,191.5	48.41	44.34
9×2	7,308.3	4,076.40	4,191.5	79.28	74.36
4×6	7,312.5	3,412.90	3,466.6	114.27	110.94
6×4	12,183.3	3,412.90	3,466.6	256.97	251.44
4×7	6,469.2	5,209.60	6,952.6	24.18	—6.96
7×4	7,341.7	5,209.60	6,952.6	40.92	5.96
6×9	6,762.5	3,660.25	3,961.3	84.75	70.71
9×6	11,312.5	3,660.25	3,961.3	214.21	185.57
6×11	14,358.3	3,489.0	3,618.8	311.53	296.77
11×6	6,629.0	3,489.0	3,618.8	89.9	83.18
7×9	8,102.1	5,456.95	6,952.6	48.47	16.533
9×7	6,695.8	5,456.95	6,952.6	22.70	—3.69
9×11	12,479.2	3,790.50	3,961.3	229.22	215.02
4×2	15,366.7	3,829.05	4,191.5	301.32	266.61
6×2	7,625.0	3,775.35	4,191.5	101.96	81.91
7×6	4,972.9	5,155.90	6,952.6	—3.55	—28.48
9×4	10,823.8	3,713.95	3,961.3	191.43	12.13
11×4	11,456.2	3,542.70	3,618.8	223.73	85.13
11×7	6,131.7	5,285.70	6,952.6	16.00	—11.91

C.D. at 5 % 1565.25.

(4) *Cauliflower (Brassica oleracea var. botrytis)* :

Among the mid-season varieties, two varieties from German Democratic Republic, Success and Delft Market, were found to form good quality curds. The curds came to maturity in 90-95 days and were very compact, solid and snow white in colour with diameter 25 to 30 cm. The individual weight varied from 10 to 20 lb. Under replicated trials 17 late varieties were tested for yield performance. The standard variety Snowball-16 produced at Katrain Sub-station showed the best performance.

(5) *Cabbage (Brassica oleracea var. capitata)* :

Two sets of replicated trials were conducted. The first was to test the recommended variety Golden Acre (IARI) against other ball head types. None of the varieties proved superior to the standard variety. However it was found that Glory of Enkhuizen produced bigger hard heads. In another trial, standard Drumhead variety was tested with other varieties in the collection. No variety was significantly superior. But EC 10113 produced better and uniform heads and was also found to do well at Katrain Sub-station.

(6) *Cowpea (Vigna sinensis)* :

The previous year's findings regarding the efficacy of plant regulator applications were tested again. It was found that MH at 15 ppm and 2, 4-D at 3 ppm when sprayed in the pre-flowering stage increased the pod yield by 28 and 26 percent respectively over the control.

(7) *Watermelon (Citrullus vulgaris)* :

A study was conducted to observe the effect of plant regulator sprays on the modification of sex ratio and yield in watermelon. In the variety New Hampshire Midget, TIBA at 100 and 200 ppm, MH 200 and 400 ppm and GA at 25 and 50 ppm, significantly increased the yield. The results are presented in the following table.

Treatment	No. of female flower per vine	No. of male flowers per vine	Sex ratio	Mean No. of fruit set	Percentage of fruit set	Mean yield in Kgm. per plot
MH 100 ppm	49.75	441.50	1 : 8.87	7.25	14.57	18.65
200 ppm	49.50	461.00	1 : 9.31	9.58	19.35	23.59
400 ppm	56.50	491.50	1 : 8.70	11.42	20.21	20.50
600 ppm	52.00	437.00	1 : 8.40	10.67	20.52	17.67
NAA 50 ppm	50.00	461.75	1 : 9.24	7.58	15.16	12.12
100 ppm	50.75	459.50	1 : 9.05	7.75	15.27	20.05
150 ppm	48.00	433.25	1 : 9.03	7.42	15.46	14.95
IAA 50 ppm	53.00	480.30	1 : 9.06	9.83	18.55	19.84
100 ppm	50.00	463.00	1 : 9.26	7.66	15.32	14.45
TIBA 100 ppm	101.50	645.00	1 : 6.35	19.08	18.80	32.65
200 ppm	82.25	562.25	1 : 6.84	16.00	19.45	37.53
GA 10 ppm	73.50	578.00	1 : 7.86	13.75	18.71	17.80
25 ppm	62.75	652.75	1 : 10.40	11.58	18.45	25.22
50 ppm	57.25	673.25	1 : 11.76	10.17	17.76	22.72
100 ppm	56.00	674.50	1 : 12.04	9.75	17.41	17.12
Control	62.25	656.00	1 : 10.47	7.50	12.05	12.31
SE _m	±6.628	±50.14	..	..	±1.6	±3.89
LSD at 5%	13.32	100.78	..	..	3.2	7.82

(8) *Co-ordinated Scheme (ICAR) on watermelon and muskmelon :*

Seven varieties of watermelon emerged promising from the yield trials, they were New Hampshire Midget, Rhode Island Red, Early Surprise, Asahi Yamato, Fuken Mudi-rigo, Nugoaba Koahi and Russian. Triploid seeds, obtained through colchicine treat-ment, in New Hampshire Midget variety were sown and fruits were found to contain non-viable seeds with well developed seed coat.

III. Fruit and Vegetable Preservation Section*1. Survey of the industry :*

During the visits to fruit preservation factories in Madras, Bangalore, Nagpur, Ludhiana, Amritsar and Panipat, technical problems like spoilage in pickles, colour deterioration in tomato sauce, quality of raw materials, bulk storage of tomato juice for ketchup making etc. were discussed.

2. Canning :

(a) *Peas*.—Varietal studies showed that Bonneville, Early Giant, Yates Early crop and Duke of Albany would be good canning types thus confirming previous years' findings. During the year some new varieties like Marrowfat, American Wonder, Telephone and Lincoln were found to be good canning varieties.

(b) *Tomato*.—Canning trials on 'whole tomatoes' (a product in great demand by Defence forces) were initiated with eighteen varieties. Treatments like dipping in CaCl_2 solutions before canning and addition of calcium chloride to the canned product were tried for improvement in quality of the packs. Storage tests were in progress.

(c) *Litchi*.—Storage tests with canned litchies, up to a period of $1\frac{1}{2}$ years, have confirmed the previous findings, namely that Bedana and Dehraduni varieties were good canners, while Longia variety was unsuitable.

(d) *Loquat*.—Two varieties Pale Yellow and Golden Yellow were found unsuitable for canning.

(e) *Grape*.—Grape varieties grown in the Division were canned in 30° and 40° brix syrup following the usual exhausting and processing conditions.

3. Indian preserves :

(a) *Apple*.—Apple murrabba in thick sugar syrup undergoes osmophilic yeast fermentation during the course of its manufacture. To find out the importance, if any, of this fermentation fifteen strains of yeast, isolated from commercial samples, were studied for various characters.

(b) *Amla*.—Amla preserve undergoes severe loss (about 90 to 95 per cent) of Vita-min C and heavy leaching of tannins during its preparation. During storage, the surface layers of the preserve was found to get darkened. Pre-treatments like soaking puncturing and blanching were found to be responsible for heavy losses of vitamin C and tannins. The data in respect of two varieties are presented below:

Analysis	Banaras Variety		Local Variety	
	Before blanching	After blanching	Before blanching	After blanching
1. Average size (cm.)	4.53×3.84	..	2.67×2.32	..
2. Stones (percentage by wt.)	9.0	..	17.5	..
3. Vitamin C (mgm/100 g)	339.3	15.6	400.0	13.0
4. Acidity (percentage w/w as citric)	1.92	0.58	2.50	0.45
5. Tannins (percentage w/w)	4.06	0.81	5.60	0.56

Factors affecting the loss of vitamin C during processing are under investigation.

4. *Drying and dehydration:*

(a) *Peas*.—A number of treatments on drying and dehydration have been tried and the results were encouraging. Suitable temperature for dehydration in a natural cabinet drier is 65°C in the beginning and 60°C later.

(b) *Mango*.—Studies on dehydration of raw mango slices have shown that a temperature of 55°C in the beginning and 45°–50°C later give satisfactory results in a natural cabinet drier.

5. *Pickles and chutneys:*

(a) *Mango*.—Mango slurry prepared by macerating raw mango slices, with an equal weight of 10 per cent brine, was preserved with (a) 1000 ppm SO₂, (b) 1 per cent acetic acid and (c) in both (a) and (b). Storage in polythelene jars was found unsuitable while no adverse effects were noted in glass, plastic or polythelene containers.

6. *Juices and beverages:*

(a) *Mandarin juice*.—(i) *Varietal trials*.—The preserved juice of a variety was found to remain completely free from bitterness and to retain good flavour during eight months of storage. In the case of Kaula, Nagpuri and Lahore Local varieties, bitterness developed immediately after preservation. Sweetened beverages, however, were not found to deteriorate in all the varieties.

(ii) *Preservation studies*.—Investigations were carried out on the efficacy of heat and chemicals. Freezing in tin cans was found to be the best and colour, odour, taste and vitamin C were retained. For retention of best colour up to six months optimum level of orange yellow pure spectrum colour was found to be 50 ppm. Flavour was better retained with “oil of sweet orange K” than with other oils. Two strains of yeast and three of mould isolated from spoiled products were identified. The mould spores were found to be more resistant than yeasts to chemical preservatives *viz.* SO₂, sodium benzoate, sorbic acid. Rates of destruction curves of yeast strains at 45°, 50° and 55° C were found to be non-logarithmic in nature. The yeast showed greater resistance in natural juice than in neutral phosphate buffer.

(b) *Studies on fortification with vitamin C*.—Natural vitamin C of orange squash, pineapple squash, orange juice, mango pulp, tomato juice and apple juice was found to be better retained in storage than synthetic ascorbic acid, except in the case of last two. Percentage retention increased, however, with the level of fortification; being maximum in canned tomato juice with mango pulp, pineapple squash, mango squash, apple juice and orange juice coming next in order of merit. Carotenoids and ascorbic acid appeared to protect each other. Browning in general increased with the level of fortification. Addition of 50 mgm. ascorbic acid per 100 gm. of orange juice and 100 mgm., for other products, is recommended for general improvement in the quality of these products. Amla extract in general was not found very useful as a source of vitamin C for fortification of the above products.

(c) *Varietal trials in squashes*.—(i) *Lemons*.—Seven varieties of lemons, were studied and juice recovery was found to range from 33.2 to 52.4 per cent with 6 to 7 per cent soluble solids, 3.7 to 5.8 per cent acidity (as Citric) and 11.6 to 35.2 mgm. ascorbic acid per 100 gm.

Studies were made of the different varieties of tangelos and two of sweet lime from the Division's Orchard. Optimum picking maturity standards were determined from physico-chemical analysis.

IV. Floriculture Section

1. *Roses (ICAR Scheme):*

(a) *Varietal collections.*—Fifty eight rose varieties belonging to all classes including different *Rosa* species from various countries were introduced taking the progressive total of collection to 664. Dr. B. P. Pal, donated buds of latest varieties like Garden Party, Montezuma, White Bouquet from his personal collection. Two species *Rosa damascena* and *Rosa alba*, said to be high oil bearing species, were introduced from Bulgaria through Plant Introduction Organisation. From Kulu Valley, *Rosa moschata* and *Rosa multiflora* were obtained and *Rosa sericea* was introduced from Nepal, through the courtesy of Scientific Expedition to Himalayas.

(b) *Performance studies.*—Preliminary observations were recorded on single plants of 80 introduced varieties. Observations were recorded on the performance of rose seedlings bred by Dr. Pal. Seedling No. 7 was found to be superior in respect of colour, quality of blooms, free flowering habit and fragrance of flowers. The flowers were not damaged by frost and open well even under severe winter conditions. Another selection namely No. 24 turned out to be promising, in the next batch of seedlings bred by Dr. Pal in 1960. Profuse flowering, attractive colour are the chief attributes of this selection.

(c) *Mutation studies.*—The plants were raised from bud sticks irradiated with varying doses of X-rays. Four varieties McGredy's Sunset, Frensham, Charles Mallerin and Virgo were under study.

Observations were recorded on the natural bud sport of Madame Driout. Except the flower colour all the other characters remain unchanged. Another bud sport in the variety of Beryl Ainger, was observed and the differential characters of the mutant and parent are given below :

Bud sport	Original variety Beryl Ainger
(1) <i>Flower shape.</i> —Flat, freely opened showing its centre at full opening.	Bowl shaped, freely opened, showing its centre and stamens at full opening.
(2) <i>Flower colour.</i> —Bright rose pink lighter towards the apex.	Buff yellow and deeper yellow towards the centre.
(3) <i>Flower size.</i> —11.5 cm. (Full stretched across).	10 cm. across (Full stretched).
(4) <i>Number of petals.</i> —25	23
(5) <i>Fragrance.</i> —Mild rose fragrance	Very light musk rose fragrance.

(d) *Hybridisation.*—Crosses with different combination were made among parent with high seed setting character. Parents like General Mac Arthur, Charles Mallerin like, Crimson Glory, Spartan and Seedling No. 7 were selected.

2. *Annuals:*

(a) *Selections.*—Assessment of different varieties available in the collections was made. Preliminary selections were carried out in Rock Dianthus, Double and Single Dianthus, Antirrhinum (tall and dwarf), Phlox, Carnation and Petunia.

(b) *Introductions.*—New introductions from commercial nurseries of U.K. and U.S.A. were made, in Pansy, Aster, Petunia, Carnation, Sweet Peas, Stock, Marigold and Verbena etc. Bulbous plants of nine types received from Katrain were also planted for study.

V. Vegetable Breeding Sub-station, Katrain (Kulu Valley)

1. *Breeding of early, mid and late varieties :*

(a) *Selection*.—Six varieties of cabbage viz., EC 10112, EC 8986, EC 12847, EC 6774 and EC 10122, were found to out-yield the standard variety Burpee significantly. None of the 23 varieties of cauliflower obtained indigenously and from abroad was superior to the standard variety *Snow Ball*—16.

(b) *Hybridisation*.—Selections were continued in the F₅ generation and F₄ back-cross generation of the European × Asiatic crosses of turnip. Similarly in carrot, selections were made from different generations of Asiatic × Nantes crosses. In beet, selection of roots in the F₂ generation of the cross between multigerm (Crimson Globe) and monogerm (EC 13901) were made. In the cross between Black × Japanese White Radish plants with late bolting habit were selected and maintained.

2. *Evolution of self-incompatible but cross-compatible inbred lines and production of hybrid seeds :*

(a) *Cabbage*.—Testing of inbred lines in Golden Acre and Drumhead for homozygosity, was continued. *Inter se* crossings were attempted in heterozygous lines for further testing.

(b) *Knol khol*.—Out of 24 inbred lines tested, eight were found to be homozygous and these were maintained.

(c) *Heterosis*.—Six varieties of cabbage Drumhead type were used as parents and 15 F₁ hybrids were studied with diallel analysis technique, in respect of characters controlled by genes. In general, heterosis was found to be manifested in terms of larger sized heads and higher yield. The hybrids tended to be earlier in maturity. Complete dominance was observed in the number of marketable heads, net weight of heads and (late or early) maturity, while over-dominance was present in yield. Non-allelic interaction particularly of complementary nature, was observed in almost all the characters. In case of maturity, there was a pronounced additive gene effect with only a slight indication of gene interaction. A predominance of dominant alleles was found in all the characters except yield in which there were more recessive alleles. It was not possible to ascertain the order of dominance of the parents except in case of maturity in which this could be determined to some extent. From these observations, it becomes evident that it would be advantageous to adopt heterosis breeding for improving the economic characters in cabbage.

3. *Mutation studies :*

In French bean (bushy type) X₂ progenies were studied. A large number of chlorophyll mutants and nine green podded mutants were recovered. Some X₃ progenies of X₂ green podded mutants were found to be true breeding while in some, segregation was noted. A pole type of mutant with green pods was observed in X₃.

4. Improvement of existing varieties Yolo Wonder in capsicum and Pusa Purple Clustered in brinjal, by inbreeding and selection was continued.

5. *Floriculture work :*

(a) *Collection of annuals*.—The study of the 42 varieties of Aster, 26 of Calendula, 5 of Delphinium, 25 of Pansy, 13 of Stock and 13 of Hollyhock besides allied species were continued.

(b) *Bulbous plants*.—The investigations on 42 varieties of Daffodils and Narcissi, 6 of Tulips, 42 of Gladiolus, 11 of Hyacinth and 2 of Freesia were enhanced. In Narcissus, a great variation in the period of blooming was discerned in the varieties, while in Daffodils, such variation was not available.

(c) *Shrubs*.—Collection has been initiated. Till now 1 of Camellia, 5 of Hydrangea, 7 of Fuchsia and 21 of Buddleia have been collected.

(d) *Evolving improved strains*.—Selections of promising types of annuals are under observation.

(e) Irradiation work in Aster with X-rays was initiated and seeds were irradiated with 10,000 r.

6. *Seed multiplication:*

Nucleus seeds of all the vegetable crops were produced with the help of bees and by hand pollination. A total quantity of 1155 Kgs and 875 gms of seeds of different vegetables were produced.

PROGRAMME OF WORK FOR 1962

I. *Fruit Section:*

- A1. Survey and collection of superior germplasm in tree fruits.
- A2. Performance of sub-tropical and tropical fruit species and varieties under Delhi conditions.
- A3. Improvement of grapes through hybridization with special reference to earliness, yield and fruit quality.
- A4. Induction and utilization of polyploidy for the improvement of grapes with special reference to seedlessness and other desirable qualities.
- A5. Improvement of guava by selection and hybridization with special reference to seedlessness and other desirable qualities.
- A6. Improvement of mango by selection and hybridization.
- A7. Induction of mutations in tree fruits through X-rays, fast neutrons and radio active isotopes.
- A8. Studies on blossom biology and sex ratio in mango.
- A9. Taxonomical studies in different fruits in citrus, mango, grapes, loquat and papaya.
- A10. Studies on propagation methods in citrus, guava phalsa and mango.
- A11. Standardization of rootstocks in citrus.
- A12. Standardization of rootstocks in mango.
- A13. Plant regulator studies in citrus, grape, mango and guava.
- A14. Survey and collection of garden tools and implements from different States and their improvement.
- A15. Studies on biennial bearing in mango.

A16. Manurial trial in mango (at Karnal).

A17. Improvement of papaya by breeding with a view to evolve superior table varieties.

A18. Breeding of temperate fruit varieties suitable for subtropical region in apple, peach and plum.

A19. Improvement of small fruits by selection and hybridization.

II. Vegetable Section :

B1. Survey and collection of cultivated and wild species and varieties of indigenous and exotic vegetables and assessment of variability in them for utilization in breeding.

B2. Breeding mid-season late and early varieties of vegetables.

B3. Studies on sex ratio in cucurbits.

B4. Studies on pollination with special reference to insect pollination.

B5. Studies on intra-sterile and interfertile lines in cauliflower.

B6. Inheritance of characters and their linkages.

B7. Studies on hybrid vigour.

B8. Studies on seed production with regard to yield and qualities in summer and winter vegetables.

B9. Studies on chemical induction of male sterility, suppression of male flowers and forcing up of female flowers.

B10. Studies on the effect of plant regulator sprays on the destruction or interruption of apical dominance.

B11. Studies on the effect of plant regulator sprays on fruitset.

III. Fruit and Vegetable Preservation Section:

C1. Survey of the fruit preservation industry.

C2. Testing of different varieties of fruits and vegetables.

C3. Investigations on Indian Preserves.

C4. Investigations on drying and dehydration of fruits and vegetables.

C5. Investigations on pickles and chutneys.

C6. Investigations on fruit and vegetable beverages.

IV. Co-ordinated Scheme for the Improvement of watermelon and muskmelon :

D1. Pure line selection will be continued.

D2. Yield trials will be continued.

D3. Intervarietal hybridization.

D4. Production of seedless watermelon.

V. Floriculture Section:

Roses :

- E1. Introductions from within the country and abroad.
- E2. Improvement through breeding.
- E3. Stock-scion relationship studies.
- E4. Manurial trial.

VI. Vegetable Breeding Sub-Station, Katrain (Kulu Valley) :

- F1. Maintenance of varieties and species.
- F2. Evaluation of self-incompatible but cross-compatible lines, study of general and specific combining ability and production of hybrid seeds.
- F3. Breeding of early, mid-season and late varieties of vegetables by selection and hybridization.
- F4. Studies on combining ability, hybrid vigour and production of hybrid seeds.
- F5. Producing useful mutations with the help of radiation.
- F6. Improvement of existing varieties by selection and hybridization.
- F7. Production of nucleus seeds in vegetable crops and their multiplication.

Floriculture :

- G1. Collection and maintenance of varieties and species of flowering annuals.
- G2. Collection and maintenance of varieties and species of bulbous flowering plants.
- G3. Collection and maintenance of flowering shrubs.
- G4. Evolving improved strains of Aster, Balsam, Calendula, Delphinium, Stock and Hollyhock.
- G5. Obtaining desirable mutants by mutagenic agents in Aster, Stock, Torenia.
- G6. Production of true breeding double Petunia seeds.
- G7. Production of nucleus seed and multiplication of seeds of improved varieties of Aster, Balsam, Calendula, Delphinium, Stock and Hollyhock and bulbs.

DIVISION OF ENTOMOLOGY

(Dr. E. S. Narayanan)

NATIONAL PUSA COLLECTION

The proper maintenance of the National Pusa Collection of insects was continued through the periodic cleaning of the specimens and replenishment of proper preservatives. Six specimens of the coreid, *Carvalhora arecae* Miller and China and two specimens of the curculionid *Meionops glaucinus* Marshall, so far not represented in the collection, were got identified and added. In addition to these a large number of insects from different parts of the country were received and these are pending identification and incorporation in the collection. The types of *Bagons trapae* Baldev Parshad; *Derispia mayae* Chatterji, Sarup and Menon; *Palorus shikhiæ* Sarup, Chatterji and Menon; and *Stortheccoris longispinosus* Menon and Ghai, described as new during the year from the Division, have been deposited in the collection.

TREATMENT OF MATERIAL IN PLANT INTRODUCTION SCHEME

Three thousand two hundred forty-six seed samples were examined, treated and phytosanitary certificates issued wherever necessary. Of these, 1401 samples were imported from 26 countries, while the remaining samples were intended for export to 47 countries. While examining these samples 22 interceptions of bruchids, psocids, *Rhizopertha dominica*, *Oryza philus surinamensis*, mites, curyatomids, *Tribolium* sp., *Sitophilus* sp., *Trogoderma granarium* and *Sitotroga cerealella* were made.

PLANT PARASITIC NEMATODES

Roots of tomato plants were found to be heavily infested by root-lesion nematode, *Pratylenchus pratensis* Filipjev. Symptoms consisted of poor growth, root integration and presence of necrotic areas. An application of 0.2% diazinon near the root-zone materially reduced the nematode population.

Surveys indicated that the percentage of infestation of root-knot nematode ranged from 2.8% to 82.5% on different crops.

Examination of shoot length, root length and leaf or leaflet area revealed that in the infested plants of bhindi, tomato and papaya, these were reduced to almost half the size when compared with those from healthy plants.

Studies on the biology of *Meloidogyne incognita* Chit. revealed that the total duration of the life cycle varied with months and ranged from 29 to 44 days.

SYSTEMATIC ENTOMOLOGY

Curculionidae (Coleoptera).—A revision of the genus *Cyrtozemia* was taken up. *Cyrtozemia cugnata* Marshall was found to be a pest of vegetables and flowering plants in Delhi. A new aquatic weevil, infesting the water nut, *Trapa bispinosa* Roxburgh, was found to be new and described under the name *Bagos trapae*, sp. n. Two more curculionids, *Nassophasis albomaculatus*, sp. n. collected at light and *Apion tamarixus* sp. n. breeding on *Tamarix gallica* in the institute estate, were found to be new to science and described.

Ichneumonidae (Hymenoptera).—Faunistic studies on the sub-family Ichneumoninae, on the lines of Fauna of India Series, were taken up.

Chalcididae (Hymenoptera).—Further specimens of chalcids were collected and were under study towards a monographic revision of the family.

Tenebrionidae (Coleoptera).—A new species of *Derispia*, named *D. mayae*, collected on algal masses at Kodaikanal in South India and a new species of *Palorus*, *Palorus shikhae*, predating on the grubs of the storage pest, *Latheticus oryzae* Waterhouse, collected from South India were described.

INSECT PARASITOLOGY

When females of *Chelonus rufus* Lyle were offered 35 eggs of *Corcyra cephalonica* St. each day till their death, it was observed that the distribution of progeny was almost uniform during the first three days, while it was very irregular from 4th to 8th day and further heavy superparasitism was observed. The maximum number of parasite eggs dissected from a single host egg was eleven. The average number of eggs laid by a female parasite was 30.6 per day, the maximum and minimum being 47 and 21 respectively. Female parasites were observed to oviposit as readily in freshly laid host eggs as in the older ones. In the former, the parasite eggs were laid outside the host embryo, while in the case of the latter it was laid inside.

Vipio deesae (Cameron) was observed to parasitise only 6.8% of the population of the top shoot borer of sugarcane, *Scirpophaga nivella* Fabr., at the institute farm. It was estimated that 26 samples of 20 larvae each, would be required to give a reliable estimate of the parasite population.

Study of samples of malformed mango shoots and soil around mango trees collected from Delhi, Saharanpur and Lucknow revealed the presence of predatory mites in addition to phytophagous ones. The predatory mites were : *Typhlodromus* sp., *T. nesbitti* and *T. rhenanus* belonging to family Phytoseiidae, *Cheletogenus ornatus*, belonging to family Chelytidae and some unidentified mites belonging to family Aceosejidae.

Laboratory experiments using *Corcyra* larvae as host, showed that at low parasite density and high or low host density, *B. brevicornis* was intrinsically superior to *B. gelechiae* both in survival and sex-ratio. At high host and high parasite density neither of the two parasite species was superior to the other, while at low host and low parasite density *B. brevicornis* was superior.

About 1,60,000 *Corcyra* moths emerged and laid about 290.0 c.c. of eggs, which were used for the mass multiplication of *Trichogramma* and other parasites as well as for maintaining the *Corcyra* culture. About 13,00,000 *Trichogramma* parasites were reared during the period. The cultures of *Apanteles angaleti*, *Bracon brevicornis*, *B. gelechiae*, *Vipio deesae* and *Chelonus rufus* were maintained.

Survey and collections of parasites were made in Kashmir and in Eastern Madhya Pradesh. A *Bracon* sp. was found parasitising the grubs of Rice Hispa (*Dicladispa armigera*) in Madhya Pradesh. The percentage of parasitism in one particular sample was about 9%. Material collected in Kashmir included representatives of two genera of parasites (*Bracon* and *Ephedrus*) so far not recorded from the India Union. A list of about 25 parasites recorded or described from India and not included in Thompson's catalogues of parasites and predators of the Commonwealth Institute of Biological Control was compiled.

INSECT ECOLOGY AND TOXICOLOGY

In the control schedule for cotton, after reviewing the data of four years experiments, the following schedule of four sprayings and five treatments was planned for trial during the year : (a) Sevin, (b) DDT+endrin, (c) endrin+parathion in all the four sprayings, (d) parathion, BHC, endrin and DDT, and (e) BHC, endrin, Sevin and endrin in the four successive sprayings.

Kelthane, Trithion, Phorate, parathion, phosdrin, Aramite, malathion, thiometon 'Rogor 40' and diazinon were tested as ovicides against the sugarcane mite *Schizotetranychus andropogoni* (Hirst.). Kelthane and Trithion were found to be effective. Studies on the residual toxicity of six pesticides to this species showed that Kelthane and Trithion were most potent, being effective up to 20 and 10 days respectively after spraying on sugarcane.

Eighteen different pesticides were screened against the palm mite *Raoiella indica* (Hirst.). Trithion, 'Rogor 40' and parathion were found to be promising. Of the 8 insecticides treated as ovicides only Kelthane at 0.1% concentration resulted in 23% reduction in hatching of eggs.

A 10% Lindane E. C. was formulated which when sprayed, kills all the insect pests and parasites that come in its direct contact. After spray has dried the leaf defoliating *Locusta migratoria* continues to die because of the ingestion of lindane while *Bracon brevicornis* which only sits on films does not die.

The ecological studies on Phadka were continued. The maximum emergence of nymphs was recorded about 10 days after the onset of monsoon, and 10—14 days after emergence the nymphs continued to remain on the bunds. Dusting the bunds with 2.5% BHC effectively controlled the pest.

The development of *Trichogramma evanescens minutum* Riley for the construction of biometer at various constant and fluctuating temperatures and relative humidities, showed that 12° C and 35% and 75% R.H. and 35° C and 75% R.H. were unfavourable for the completion of development. The maximum number of eggs were laid at 25° C and 75% R.H. whereas there was no egg laying at 15° C and 35° C. There was no development in the field during April, May and June when the maximum temperature during the month was above 35° C. for 6—14 hours daily.

A mutant of cotton bug, *Dysdercus koenigii* (Fabr.) was observed in the laboratory. It could be distinguished from the normal red form in possessing grey colour during the nymphal stages and ochraceous in the adult stage. Genetic analysis of colour variation showed that it was a recessive mutation involving a single gene, the red type body colour being dominant over the grey.

SECOND FIVE-YEAR PLAN SCHEMES

1. Entomological investigations with the help of radioactive isotopes

Experiments were carried out to label the adults of *Bracon brevicornis* Wesmael with beta-emitter, radioactive phosphorous (P^{32}). It was observed that by rearing the parasites on full grown caterpillars of *Corcyra cephalonica* Stainton, made radioactive by allowing them to feed on crushed 'Jowar' mixed with P^{32} , radioactive adults of the parasite could be obtained. Sufficient radio-activity in the adults was obtained without adversely affecting their general behaviour by rearing them on caterpillars with radioactivity ranging from 4,500—8,000 c.p.m. (6.4 per cent efficiency of the counting system). It was further observed that the radioactivity in the adults is lost with the passage of time through excretion and egg laying, the loss being more in the latter case. Further, biological half-life of P^{32} in the parasite (*B. brevicornis*) was also determined and was found to be seven days. Biological half-life of P^{32} in red cotton bug (*Dysdercus koenigii* Fabricius) was also determined. Research work on the effects of gamma radiations from cobalt-60, on storage pests was started.

2. Biological testing and certification of insecticides

Ten insecticides were tested to determine their relative toxicity against *Aphis maidis* infesting barley.

Twenty-one insecticidal samples received from Government and commercial establishments were tested for insecticidal properties and compared with laboratory standards, using different test insects. 2-n-aminyl-3 piperonyl acrolein received from the Division of Chemistry and tested against *Tribolium castaneum* adults was found to be effective as a synergist of pyrethrins when used in the ratio of 9 : 1, the toxicity increased by about four times as compared to pyrethrins alone.

Pronounced gustatory repellent effect of neem seed suspension was observed against the adults of *Schistocerca gregaria* and *Locusta migratoria*. No feeding was observed in plants treated with 0.05% neem seed extract suspension.

3. Locust Toxicology

Experiments for the determination of LD_{50} of dieldrin and diazinon spray were carried out and further trials with aldrin and lindane sprays were also being conducted against the third stage hoppers and adults of *Schistocerca gregaria*.

Semi-synthetic diets consisting of different combinations of dry cabbage leaf powder, wheat bran, whole milk powder and Brewer's yeast, fed to *Schistocerca gregaria* indicated that the rate of growth in the diet consisting of cabbage leaf powder, wheat bran and Brewer's yeast (2:2:1) was very much near to those fed on fresh cabbage leaf. Eggs laid by locusts reared on cabbage leaf powder, whole milk and wheat bran (2:2:2) were not viable.

Out of 8 chemicals tried so far, safrol was found to be the most attractive to the first stage hoppers of *S. gregaria*.

4. Ecological studies on stored grain pests

Studies on the development of *Trogoderma granarium* Everts on wheat at constant temperatures viz., 20, 25, 30, 35, 40 and 45° C and relative humidities of 30, 45, 60, 75, 90 and 100%, showed that the pest thrived best at 35° C whereas at 40° C the mortality in the egg stage was more and at 20° C they did not hatch at all. The development of the pest in different air and CO₂ mixtures and on the par-boiled and raw rice, was studied. The pest was observed to prefer raw rice. Confirmatory studies were being continued.

Studies on the development of *Callosobruchus maculatus* under different ecological conditions revealed that the life-cycle at 20° C occupied about 10 days while at 35° C it was about 30 days. The experiments on the damage caused by this pest in 'mung' stored in different types of jute bag indicated that 'mung' stored in bags made of B-Twill (sacking) or plain weave (Hessian) was not infested. Those stored in bags made of plain weave (sacking) were found to be infested.

5. Seed Testing

Sixty-six samples of vegetable seeds namely, beans, brinjal, bottle-gourd, cabbage, cauliflower, pea, pumpkin, sem and tinda collected from the Punjab, Uttar Pradesh, Rajasthan, Maharashtra and Madras were tested. About 83% of the samples were damaged by insects and rodents. The maximum damage (100%) was observed in sem by *Bruchus* spp., *Rhizopertha dominica*, *Trogoderma granaria* and *Sitophilus oryzae* and in pumpkin by *T. granaria*. The damage in other seeds was 53% in tomato by *Stegobium paniceum*; 5% in pea by *Bruchus* spp.; 5% in cucurbits by *Rhizopertha dominica*; 5.6% in Okra by *Spermophilus* sp. and bollworms; 11, 7 and 3% in cabbage, cauliflower and brinjal respectively by field insects. *Corcyra cephalonica* was recorded damaging the seeds of cabbage, cauliflower, turnip and radish in stores.

6. Insect Physiology

Out of 500 varieties of *Sorghum vulgare* screened for *Chilo zonellus* susceptibility, 150 varieties were planted to see the effect of *Chilo* infestation on each variety. Observations indicated that selections like 'Adhroo' and 'Satpani' withstood infestation much better than the rest of the varieties. Studies were initiated on the larval antibiosis exhibited by different varieties under laboratory conditions.

It was found that the *Lasioderma serricornis* larvae could develop in the total absence of cholesterol which was supplied to the host by microbial synthesis.

Studies on the qualitative and quantitative requirements of *Tribolium castaneum* indicated that this species reacted differently under the deficiency of certain factor of vitamins of B-complex. While riboflavin, nicotinic acid and pantothenic acid were vital for the growth and survival, pyridoxin, folic acid and biotin were found to be important. Inositol which was of little or no value to most of the insects, was found to be necessary for *Tribolium castaneum*.

7. Indian Honey Bee Scheme

Pedigree breeding.—February was found to be most favourable period for queen rearing. Pedigree stock Nos. 2, 8, 9, 10, 16, 18 and 27 selected at Pusa had done well throughout the year. Similarly, colony numbers 1, 2, 7, 13, 17, 19 and 20 at Muzaffarpur showed good performance all the year round.

Bee behaviour.—Comparison of brood rearing activity showed that special care of colonies was called for during summer and monsoon months. Brood rearing was at the lowest ebb during June and July and again increased slightly during August with the flowering of maize. Jeolikote size hives had always more brood than Newton size hive.

Bee biometry.—Material collected from Uttar Pradesh was studied. It was found that the mean tongue length of *A. indica* F. from the plains was 4.9849 mm. ± 0.0072 and that from hilly areas 5.2701 ± 0.0045 .

Requirement of coriander for insect pollination.—Studies on insect survey carried out at Pusa showed that honey bees constituted by far the largest number among the insect visitors to coriander blossoms. *Apis florea* played a major role in the pollination of coriander and for increased seed setting.

I.C.A.R. SCHEMES

1. Exploration of toxicity hazards in the use of modern insecticides against cattle and human beings

Experiments carried out on the effectiveness of malathion, pyrethrins and pyrethrin + piperonyl butoxide, when impregnated on jute bags against *Tribolium castaneum*, *Rhizopertha dominica* and *Trogoderma granarium* showed that malathion and pyrethrins even up to 300 mg./sq. ft. were ineffective, while pyrethrins + piperonyl butoxide at the same dosage caused about 54.6% kill of *Tribolium castaneum* adults. All the three treatments at the rate of 300 mg./sq. ft. were quite effective against the adults of *Trogoderma granarium* and *Rhizopertha dominica*, while against *T. granarium* larvae pyrethrins + piperonyl butoxide gave only about 45.3% mortality.

Studies on the relative efficacy of different types of jute bags against penetration of stored grain pests and contamination of grains with insecticides from surface treatment of the bags showed that tightly woven hessian type jute bags were better than the commonly used B-Twill sacking type.

2. Biology and nutrition of insect pests of agricultural importance

Studies on the developmental behaviour of *Tribolium castaneum* on cereals, millets and pulses showed that the larvae could not develop on whole grains while in flour there was development in several cases.

Experiments on the quantitative requirement of thiamin, riboflavin, nicotinic acid pantothenic acid and folic acid for the growth and development of *Trogoderma granaria* larvae showed that the growth was normal in the absence of thiamin, but it was somewhat retarded when the dose of thiamin was increased from 25 μ g. to 50 μ g. per grain of diet. No larva could reach the adult stage in the absence of riboflavin, nicotinic acid or pantothenic acid but the growth was normal when these vitamins were added even in small doses i.e., 3.1 μ g./gm.

PROGRAMME OF WORK FOR THE YEAR 1962

Section of Parasitology :

1. Study of biology and bionomics of insect parasites and predators.
2. Fundamental studies in insect parasitism.

3. Studies on the coefficient of parasite-efficiency.
4. Mass breeding of hosts and parasites.
5. Field and laboratory studies on the parasites and predators of aphids.
6. Studies on predatory mites.
7. Studies on Indian Mymaridae.
8. Scheme under the Second Five-Year Plan :
 - (i) Survey and collection of beneficial parasites and predators in the Indian Union.
 - (ii) Studies on Indian Braconidae.

Section of Insect Ecology and Toxicology :

1. Studies on the development and distribution of insects under different ecological conditions.
2. Studies on population determination and assessment of damage.
3. Effect of chemical control on the biological balance of cultivated crops.
4. Factors responsible for variation in the susceptibility of insects and the toxicity of insecticides.
5. Bioassay of fumigants.
6. Studies on the effect of contact insecticides (DDT, BHC, dieldrin) and fumigants (CS₂, HCN and chlorosol) on the insect infestation in stored grains and the viability of seeds.
7. Field and laboratory tests with pyrethrins against important crop and stored grain pests.
8. Laboratory tests on the chemical control of the Desert Locust in flight and situ.
9. Plant Introduction.
10. Schemes under the Second Five-Year Plan :
 - (i) Entomological investigations with radioactive isotopes.
 - (ii) Biological testing and certification of insecticides.
 - (iii) Ecological studies on the insect pests of stored grain.
 - (iv) Testing and certification of improved varieties of seeds.
 - (v) Bee-Keeping :
 - (a) Breeding and raising of bee colonies of *Apis indica* headed by pedigree queen.
 - (b) Studies in bee behaviour.
 - (c) Role of bees in seed setting.
 - (vi) Locust Toxicology.

Section of Systematic Entomology :

1. Taxonomy of Indian Curculionidae (Coleoptera).
2. Taxonomy of Indian Aeshnidae (Odonata).
3. Studies on Indian Ichneumonidae (Hymenoptera).
4. Review of the Chalcididae (Hymenoptera).

5. Taxonomy of Indian Tenebrionidae (Coleoptera).
6. Studies on *Lasioderma serricorne*.
7. Studies on Noctuidae (Lepidoptera).
8. Studies on Indian Pyralidae (Lepidoptera).
9. Studies on Indian Acarina (Acaridae).

Section of Insect Physiology :

(Scheme under the Second Five-Year Plan).

1. Studies on resistance to *Chilo zonellus* Swinh. In maize and sorghum. (In collaboration with the Division of Botany.)
2. Studies on aphid resistance in mustard.
3. Nutrition of insects associated with plants and plant products.
4. Rearing of beneficial insects including parasites on artificial and semi-artificial media.
5. Intracellular symbiotes of insects and their physiology.
6. Studies on the development of insects on several natural and semi-natural foods.
7. Effects of micro-nutrients on insect growth.
8. Analysis of insect and plant tissues.

DIVISION OF MYCOLOGY AND PLANT PATHOLOGY

(Dr. R. S. Vasudeva)

A. SECTION OF PLANT PATHOLOGY

1. Wheat (*Triticum aestivum* L.) :

(a) *Rusts* (*Puccinia graminis tritici* (Pers.) Erikss. & Henn., *P. triticea* Erikss. and *P. glumarum* (Schm.) Erikss. & Henn.).—Over 450 field collections of the three rusts, obtained from different parts of the country, were analysed for the study of physiologic races and races, 14, 15, 15-C, 17, 21, 21-A, 21-A-1, 24, 34, 34-A, 40, 42, 42-B, 88, 117 and 189 of black rust; races 10, 11, 17, 20, 63, 77, 106, 107, 108, 162 and 162-A of brown rust; and races 13, 19, 20, 31, A and G of yellow rust were met with. Races 21-A, 40, 117, 42-B and 34 of black rust; races 162, 77, 10 and 20 of brown rust; and races 19, 31 and A of yellow rust were most prevalent and widely distributed in the order given above. Black rust samples, collected recently in Nepal, yielded races 15-C, 21, 21-A, 21-A-1, 24, 40, 42 and 42-B, all of which are already recorded from India. Similarly, no new race of brown rust could be picked up from Nepal collections; the races isolated being 11, 63, 77, 107 and 162.

In the studies to determine the role of alternate hosts in the perpetuation of rusts, seedlings of wheat were inoculated with aeciospores occurring naturally on species of *Berberis* at various places in Simla hills but no infection was obtained. Some of this material has, however, infected *Brachypodium sylvaticum* proving thereby that it is connected with the rust *Puccinia brachypodii*. In cross inoculation experiments too, the teliospores of *Puccinia brachypodii* have infected leaves of *Berberis lycium* and *B. aristata*. Teliospores of *Puccinia graminis tritici*, collected from wheat straw of 1960 summer crop in Muktinath area (3,000—3,600 meters a.s.l.) of Nepal during April-May, 1961, were found to be viable in

the tests conducted at Simla during September-November, 1961 and infected young leaves of seedlings of a species of *Berberis* which is common in Muktinath. Over-wintered teliospores on old leaves of a wild grass (unidentified) from the same area in Nepal have, on germination, caused infection of *Berberis lycium* and *B. angulosa*. Aeciospores of *Aecidium montanum* Butl. have failed to infect *Poa nemoralis* and *P. annua*, which is in conformity with previous results. Natural infection of *Thalictrum* was not observed during field surveys.

Oversummering of all the three rusts of wheat was again observed at suitable altitudes in the hills. In the Nilgiris, all the three rusts were observed all through the year on the wheat crops. Surveys on the incidence of rusts in different parts of the country showed that it was, on the whole, a mild rust year.

In seedling resistance tests, 72 wheat varieties were tested with individual races of black rust and N. P. 842, E. 4274, E. 4458, H. 39-5 (6-112-2-1), H. 39-5 (11-412-3-9), H. 59-3 (21-779) and H. 60-3 (58-726) showed high degree of resistance. Out of the 101 varieties tested, 23 proved to be resistant to mixture of black rust races. In the case of brown rust, 68 varieties and cultures were tested with individual races and four, namely, H. 45-4-239-2 Pb. 14, H. 16-23, E. 4363 and E. 4313 proved to be resistant. Eleven of the 160 varieties tested proved to be resistant to the mixture of brown rust races. In the case of yellow rust, 29 wheat varieties and hybrids were tested with individual races and H. P. 286(A), H. D. 47-197, E. 4340, E. 4360, E. 4443, E. 4444 and E. 4446 gave resistant type of infection. Out of the 107 varieties tested, 39 gave resistant reaction to mixture of yellow rust races. One hundred and seventy one varieties received from Economic Botanist, Rajasthan, were also tested with mixtures of ten races of yellow rust and three varieties, viz. H. 727-3, H. 727-4 and H-727-10 were found to be resistant. In all, nearly 24,000 wheat seedlings were tested in the glasshouse during this year. The races used in these tests were 15, 15-C, 17, 21, 21-A, 21-A-1, 24, 34, 40, 42, 42-B, 75, 117, 122 and 194 of black rust; 10, 11, 17, 20, 26, 63, 70, 77, 106, 107, 108 and 162 of brown rust; and 13, 19, 20, 31, A, D, E, F, G and H of yellow rust.

In the adult resistance tests, nearly 5-acre area under wheat was inoculated with all the three rust races at Delhi and results were recorded and selections made on over 80,000 plants. In all more than 680 'families' were recorded for the rust reaction and nearly 2,000 promising plants were selected in collaboration with the Division of Botany. In addition to this work at Delhi, similar tests were carried out at Pusa, Indore and Wellington.

Studies on the survival of black rust races in mixture were continued. It was again observed that a combination of races 117 and 122 in passage through five varieties of wheat for five generations resulted in the predominance of race 122.

In connection with the study of dissemination of spores in relation to rust out-break, slides were exposed at 25 rust nurseries where three susceptible wheat varieties had been sown. At the sub-stations of the Institute, plants of differential hosts were also raised to serve as race indicators. Exposed slides were received from 14 stations in 1960-61 but only 5 stations communicated the dates of appearance of rust. The examination of slides from these 5 stations showed that spore showers took place well before the date of rust appearance at three places, viz. Kanpur, Jullundur and Pusa.

(b) *Loose Smut* [*Ustilago tritici* (Pers.) Rostr.].—Out of the 127 wheat varieties tested for their resistance to a mixture of isolates of *Ustilago tritici* under field conditions at Delhi during 1960-61, 52 remained free from infection. Of these, eight varieties, E. 2690, E. 3097, E. 3158, E. 3320, N.P. 718, N.P. 797, N.P. 798 and N.P. 799, have consistently remained free from smut for more than three years, while five wheat varieties, E. 2636, E. 3061, E. 3065, E. 3098 and E. 3176, have remained free for the last 2 years.

In a similar test at Simla, out of the 39 wheat varieties tested, 23 have remained free, of which eleven (E. 1915, E. 4432, E. 4433, N.P. 823, N.P. 824, C. 253, H. S. 375-53-31, H. S. 375-54-104, H. S. 375-54-147, H. S. 391-54-9 and H. S. 829-58-235) have remained smut-free consistently in 2 or more tests conducted so far. Maximum infection obtained in some of the susceptible varieties at Delhi was 100% and at Simla 85.5%.

In physiological studies, the fungus has been found to be autotrophic for vitamins but aminoacids were observed to have profound effect on sporulation; and that it can utilize pectin and sucrose better than other sources of carbon. In an attempt to analyse the factors that govern the development of the disease, it was observed that date of sowing, particularly early sowing, results in low infection and that the prevalent humidity and temperature at the time of inoculation have considerable influence on infection. The soil-fertility, however, does not seem to have any appreciable effect on infection. Hot-water treatment, solar treatment or soaking the seed in plain water for different periods has been found to kill the internally seed-borne mycelium of the fungus. In an experiment to see the effect of storage of the treated seed on its viability, it was observed that the seed soaked in water for more than 12 hours showed a sharp decline in its viability after 10 months' storage.

(c) *Karnal Bunt* [*Neovossia indica* (Mitra) Mundkur].—Ninety nine wheat varieties were tested against Karnal bunt in the field at Karnal; 44 varieties in the field at Kangra; and 140 varieties in pots at Delhi. At Karnal, 14 wheat varieties showed infection and 85 remained bunt-free while at Delhi, 21 wheat varieties showed infection and 119 remained bunt-free. The corresponding figures for Kangra were 12 and 32, respectively. Maximum infection on ear-basis was observed to be 41% in N. P. 165. There was no natural incidence of the disease at Karnal and Delhi; while at Kangra it was found to be only in traces: indicating thereby that the conditions for the development of the disease this year were rather unfavourable. Nutritional studies on *Neovossia indica* have shown that the fungus grows best in the medium containing thiamine and can utilise dextrose, sucrose and raffinose better than the other 15 carbon sources tested.

(d) *Hill Bunts* [*Tilletia foetida* (Wallr.) Liro and *T. caries* (Tul.) DC.].—Out of the 85 wheat varieties (74 exotics and 11 Indian wheats) under test at Simla against *T. foetida*, 55 were found to be susceptible of which 18 varieties showed 100 per cent infection. Twelve varieties (E. 2327, E. 2462, E. 2513, E. 2961, E. 2974, E. 3025, E. 3210, E. 3214, E. 3218, E. 3388, E. 3426 and E. 4416) remained bunt-free. Tests conducted at Sillaroo with 45 promising wheat varieties against *T. caries* showed that those which were found to be immune to *T. foetida* in the previous years, were also resistant to *T. caries*. Seven wheat varieties (Omar, Burt, Rio, Emmer, Westmont, Brevor and Columbia) reported to be promising against Bunt in U.S.A. were tested with mixture of races of *T. foetida* and *T. caries*. Only Emmer was found susceptible to the latter. These varieties along with ten other promising varieties (Australian No. 1, E. 182, E. 197, E. 201, E. 2327, E. 2469, E. 2961, E. 3025, E. 3214 and E. 4416) were tested against 5 races of *T. foetida* and 7 races of *T. caries*, individually. Emmer, E. 192, E. 197, E. 3205 and E. 3214 were found to be susceptible to both the bunts.

Analysis of 27 samples of *T. foetida* and 19 of *T. caries* indicated the presence of 13 races of *T. foetida* and 12 of *T. caries*. In host-range studies under controlled conditions, *T. caries* has been found to infect *Aegilops squarrosa* and *A. crassa*. *T. foetida* infected *Lolium perenne* besides other grasses reported earlier. No natural occurrence of wheat bunt has, however, been observed on grasses so far.

During a survey of Kumaon hills, *T. foetida* was found to be prevalent over large areas, at altitudes varying from 3,700 ft. to 7,200 ft. Normally 10-15 per cent bunt infection was observed in various fields but in one field at village Siloute (4300 ft.) 80 per cent infection was recorded on local wheat. In certain fields in Upper Simla Hills and Nepal, more than 40 per cent infection was noticed.

2. Barley (*Hordeum vulgare* L.) :

Rusts (*Puccinia graminis tritici* (Pers.) Erikss. & Henn., *P. glumarum* (Schm.) Erikss. & Henn. and *P. hordei* Otth.).—Thirty seven collections of black and yellow rusts obtained from different parts of the country were analysed and races 15-C, 21-A, 40 and 119 of black rust and races 19, 31 and G of yellow rust were obtained. In the seedling resistance tests, twelve varieties were tested against individual races and 15 with a mixture of races of black rust but none was found to be resistant. With yellow rust, 192 varieties were tested with a mixture of races, out of which 50 were found to be resistant; and with individual races, out of the 10 varieties tested, six, viz. H. W. (K-39)-18, H.W. (K-58)-1, H. W. (K-58)-37, H. W. (K-57-58)-9, E.B. 158, and E. B. 240, were found to be resistant. For leaf rust of barley, *P. hordei*, 12 field collections were studied for physiologic race identification which yielded the already known races H.1 and H.2. In seedling resistance tests with the leaf rust, 57 varieties were tested but none was found to be resistant. In all, 5711 plants of barley were screened for their resistance to rusts in the glass house. In field trials (adult plants), barley varieties, their crosses and hybrids were also tested for rust resistance under conditions of artificial epidemic.

3. Sugarcane (*Saccharum officinarum* L.) :

(a) *Red Rot* (*Colletotrichum falcatum* Went).—During the year under report Red Rot appeared in the form of localised epidemic in a number of villages of Delhi State and the cane variety mainly affected was Co. 312. Isolations from the affected canes yielded light, profusely-sporing type isolates of *C. falcatum*.

The comparative virulence of 29 selected isolates of *C. falcatum* (3 dark and 26 light types) was tested on the ten standard cane varieties. Considerable differences in the virulence of the various isolates were observed. Generally speaking, the light type, recently isolated and profusely sporulating isolates, were more pathogenic. Of the isolates tested, No. 402 (a light type isolate), recently isolated from diseased canes of Co. 356 (a resistant variety) collected from Lakhimpur (Uttar Pradesh), gave maximum infection.

In the varietal resistance tests, 182 important and promising cane varieties were tested by Plug Method and 94 by Nodal Infection Method. Seven cane varieties, viz. Co. 971, 1190, 1202, 1228, 1320, B. O. 10 and B. O. 28, reacted as resistant.

In the experiment to test the resistance of 12 promising cane varieties against recent isolates of *C. falcatum* obtained from different localities in the country, most of the varieties reacted as moderately resistant against all the seven isolates tested.

In the experiment to determine the effect of mixed inocula on Red Rot infection, combinations of light and dark, light and light and dark and dark type isolates were tried on the ten standard cane varieties. The results obtained showed that mixtures of a light and a dark type isolate were more virulent than individual isolates or other combinations of light and light, or dark and dark type isolates.

In the studies on the variation of the causal organism of the Red Rot of Sugarcane, some important findings and indications of fundamental aspects have been obtained e.g. the role of PABA (Para-aminobenzoic-acid) in pathogenicity; indications of heterokaryosis resulting in heterokaryons more virulent than the either parent; increase of virulence of the pathogen by successive passage through resistant cane varieties; the development of the perfect stage of the Red Rot fungus on hosts other than sugarcane leaves indicating thereby the possibility of the change of the Red Rot organism on passing through such widely different host tissues.

The stroma-forming strain of *C. falcatum* was again obtained this year from some of the isolations made from leaf mid-rib lesions. The pathogenicity tests have shown that it is only a weakly parasitic strain.

Glomerella cingulata was also again isolated from one of the collections of diseased leaves showing typical leaf mid-rib lesions from Kerala State.

(b) *SMUT* (*Ustilago scitaminea* Syd.).—In the varietal resistance test with 112 cane-varieties at Karnal, 28 varieties showed less than 5% infection, 25 gave 5-15%, 28 showed 15-30% and 25 gave 30-50% infection, while the remaining 6 varieties gave more than 50% infection. The corresponding figures for a similar experiment at Delhi with 74 varieties were 20, 13, 19, 14 and 8.

† (c) *RUST* (*Puccinia kuehnii* (Krueger) Butler and *P. erianthi* Padwick & Khan).—Forty one samples of rust on sugarcane and allied plant species, collected or received from different parts of the country, were studied. Apparently, the rust has made its appearance in some new localities affecting a number of new cane varieties. From the samples received, ten cultures of Rusts of sugarcane, *Erianthus munja* and *E. fulvus* were established and single-spored for further studies. The technique for the maintenance of the rust on cut-leaves and pot-plants was standardized and the cultures were successfully maintained at Delhi during the hot summer months. High humidity and bright light were found to be important factors for the infection and development of the rust.

In the collateral host studies, it was observed that *Erianthus fulvus* rust, collected from Simla, could infect sugarcane, but the rusts from *Zea mays*, *Sorghum halepense*, *Erianthus arundinaceus*, *E. munja* and *Cymbopogon* sp. could not infect sugarcane. Rust cultures from a number of other wild grasses were also established on their respective hosts but none of these could infect sugarcane. However, sugarcane rust was found to infect *Saccharum sinensis*, *S. barberi* and *S. narenga*.

Indications of physiologic specialization were obtained in the pathogenicity tests of a number of rust cultures on certain cane varieties.

In the life-history studies, the uredospores have been found to retain their viability for more than 2 months at 10° C, under dry conditions and their thermal-death-point was found to lie between 53° and 55° C.

4. Linseed (*Linum usitatissimum* L.) :

Rust (*Melampsora lini* (Pers.) Lev.).—One hundred and thirty six rust collections obtained from different linseed growing tracts in the country were analysed and Indian Races I₁, I₃, I₄ and I₅, and, in addition, a new race No. I₆ were obtained. Race I₂ was, however, not met with in any collection. The new race which was picked up from Gurdaspur (Punjab) in a rust collection from 1959-60 crop appears to be most virulent amongst the known Indian races as it infects the largest number of differential hosts. There does not appear to be any particular regional distribution of these races. Their comparative prevalence was, however, found to be I₄, I₃, I₅ and I₁ in the descending order. In the varietal resistance tests in the seedling stage, of the 50 varieties tested against all the five races, individually, only one, Bolly Golden, proved to be resistant.

Pycnial and aecidial stages of linseed rust were again found in nature for the second year in succession in Kangra valley. It has been established that teliospores of this rust which get stored with the seed in the hills are able to initiate fresh infections in the local crop from where the spores are disseminated to the plains and cause infection. No evidence of overwintering of the rust in the uredostage, in nature, has been obtained.

For evolving suitable differential hosts, plants of some crosses in F₂ generation were tested against the rust races.

5. Pigeonpea (*Cajanus cajan* (L.) Millsp.) :

Wilt (*Fusarium udum* Butl.).—In pot-experiments, all the 20 varieties tested, including N.P. 41, proved to be susceptible. In field-trial, six varieties, viz. S. 37-2, S. 37-2A, S. 37-4, S. 37-4A, S. 68-4 and S. 76-4, showed less than 5 per cent infection, whereas the remaining 14 varieties showed 6 to 27 per cent infection.

6. Antibiosis :

Further studies on bulbiformin, an antibiotic from *Bacillus subtilis*, showed that the conidia of *Aspergillus niger* and *Fusarium udum* are transformed into balloon-like structures when grown in the presence of the antibiotic at concentration of about 10 dilution units. The concentration higher than this, however, induced occasional lysis. Experiments conducted to study the mechanism of action of bulbiformin on the spores of *A. niger* showed that the antibiotic probably alters the permeability of the cell-wall resulting in excessive absorption of water and thereby inducing bulb formation.

The production of bulbiformin greatly increases when dextrose was replaced by sorbitol in DAP medium. Furthermore, potassium, sulphur, phosphorus, iron and manganese were found to be essential elements for the growth and production of the antibiotic. Certain vitamins, like nicotinic acid, thiamine, biotin and pantothenic acid, and groundnut cake significantly enhanced the antibiotic production in the medium,

The difference between the antibiotic production by the radiation-induced mutant and the parent strain of *B. subtilis* was narrowed down when grown on rich synthetic media or soil supplemented with organic nutrients.

7. Physiology of Fungi :

Further studies on spore germination of *Colletotrichum falcatum*, using the ringed-slide technique, have shown that apart from spore concentration, age of the culture, pH of the germination drop, centrifugation of the spores and temperature of incubation markedly influence spore germination. Furthermore, the dimension of the germination drop, particularly the depth which directly influences the aeration of the spores, has been standardized. Self inhibition studies with different isolates of *C. falcatum* revealed that self inhibition is not a general phenomenon with all the isolates and that some isolates appear to lose their capacity to secrete the toxic principle under certain cultural conditions.

Hexose phosphates (Glucose—6—phosphate and Fructose—1 : 6—diphosphate) and calcium chloride were found to greatly increase the perithecial production of *Glomerella tucumanensis* on sugarcane leaves.

8. Effect of Atomic Radiation on Micro-Organisms :

Different levels of radioactive phosphorus ranging from 200 to 400 $\mu\text{Ci/ml}$ were used for inducing mutation in *Colletotrichum falcatum* using the growth-phase method. A number of biochemical mutants, deficient either in biotin or thiamine alone or in combination with choline, were screened. The pathogenicity tests of these mutants revealed that the virulence of most of the mutants has been impaired. Out of the 3 mutants, deficient in biotin, one is morphologically a light, sporulating type and does not show any alteration in pathogenicity whereas the other two, which are dark type, show loss of pathogenicity. It was further confirmed that the loss of pathogenicity of the biochemical mutant, deficient in para-aminobenzoic acid, can be partly restored by feeding the host with PABA through the roots,

9. Fungicides :

Comparative field fungicidal trial conducted against black rust of wheat (*Puccinia graminis tritici*) showed that four sprays of Parzate liquid plus zinc sulphate gave better results than the other four treatments. Similarly, in linseed rust Parzate liquid plus zinc sulphate reduced the infection to traces with corresponding increase in the yield.

In the trials against anthracnose of chillies (*Colletotrichum capsici*), of the 8 copper fungicides tested, copper sandoz, cupramar and Bordeaux mixture proved more efficacious for the control of the disease.

Nine seed-dressing fungicides were tried in the field against angular leaf spot of cotton (*Xanthomonas malvacearum*) and Spergon proved comparatively superior in enhancing germination and reducing the disease incidence.

In the field experiments against stripe disease of barley (*Helminthosporium gramineum*) with 9 seed-dressing fungicides, Agrosan GN checked the disease effectively.

Phytotoxicity tests conducted with 4 samples of cuprous oxide containing 2.0%, 1.0%, 0.5% and 0.0% free copper on seedlings of six crops showed no phytotoxicity except in the case of maize, where it was only slight.

A number of compounds synthesized in the Chemistry Division of the Institute were screened in the laboratory for fungitoxicity.

A strain of *Sclerotium rolfsii* has been developed during 14 generations, which can tolerate 30,000 p.p.m. of Fytolan (copper oxychloride). The tolerance for copper was found to persist even when the strain was grown for 3 successive generations on the fungicide-free medium.

10. Seed testing and plant introduction :

In the studies on ecto and endophytic seed microflora of common vegetables, over 50,000 seeds from 109 seed samples were examined and 97 isolates of different species of *Alternaria*, *Aspergillus*, *Gloeosporium*, *Chaetomium*, *Curvularia*, *Erysiphe*, *Fusarium*, *Helminthosporium*, *Nigrospora*, *Penicillium*, *Rhizopus*, *Rhizoctonia*, *Stemphylium* and *Trichoderma* were obtained. The presence of some of these fungi in the seed was found to greatly impair their germination or induce rotting of the seedlings. Cleistothecia of *Erysiphe polygoni* were observed on a carrot seed collection from Srinagar.

In connection with the Plant Introduction Scheme, about 4,000 seed samples, received from foreign countries or intended for export, were examined and suitably treated. Phytosanitary certificates were issued wherever necessary.

11. Assessment of losses due to plant diseases :

Experiments to assess losses due to Groundnut Mosaic, Linseed Rust, Maize Blight, Angular Leaf Spot of Cotton and Potato Mild Mosaic were conducted in the field.

In Groundnut Mosaic, the disease causes a reduction of 27.9, 61.1, 81.3 and 92.0 per cent in pod weight and 30.4, 64.4, 82.3 and 92.2 per cent in kernel weight at 25%, 50%, 75% and 100% disease intensity levels, respectively.

In linseed rust, the loss in yield of N.P. 12 (Moderately susceptible) ranged from 16.5-93.7 per cent while that of N.P. 21 (Highly susceptible) from 70.4-93.7 per cent depending on the time of infection and incidence of the disease and its intensity.

In the case of Maize Blight the loss in yield of grain varied from 27.6-90.7 per cent depending upon the intensity of infection. The regression Coefficient for the disease was estimated to be 17.3.

In Angular Leaf Spot of Cotton, intensity of disease on individual plants was estimated using Mc Kinney's disease index method. A comparison between disease index and yield showed no relationship between the two. Further, it was observed that there was no loss in yield so long as the disease is confined to angular leaf spot stage only and does not infect the stem.

In Potato Mild Mosaic, 2-4 weeks of masking of mosaic symptoms reduced the losses by 4-12 per cent as compared to those without any masking.

12. Miscellaneous :

(a) *Alternaria leaf spot disease of wheat*.—A highly pathogenic species of *Alternaria* which appears to be different from *A. tenuis* has been isolated and its pathogenicity proved on several durum wheat varieties and N.P. 827, N.P. 828 and N.P. 830. The adult plants have been found to be more susceptible than the seedlings.

The optimum temperature for the growth of the fungus was found to be 25°C, and for the germination of the spores, between 15°–25°C.

(b) *Downy Mildew (Sclerospora philippinensis Weston) of maize*.—The downy mildew from *kans* (*Saccharum spontaneum* L.) has been found to infect maize, indicating thereby that the disease is perpetuated on *kans*. It is suggested that eradication of infected clumps of *kans* in the vicinity of maize fields would prevent the production of the inoculum for the succeeding maize crop. Abnormal development of aerial mycelium of the mildew was observed on maize leaves under excessive humidity.

(c) *Maize Rust (Puccinia sorghi Schw.)*.—*Oxalis corniculata*, the alternate host of maize rust, has been found to be naturally infected near maize fields in Nepal Hills during April.

(d) *Grain Smut (Sphacelotheca sorghi) of jowar*.—Of the 50 sorghum varieties tested for their resistance to grain smut, eleven varieties (Co. 4, Co. 11, 4/55, G-3, GWL-82, N-3, N-10, P. J. 16K, J.P. 9, Ujjain-6, Ujjain-8) remained disease-free, whereas maximum infection upto 64.3% was obtained in I.S. 1018.

(e) *Diseases of fruits and Vegetables*.—Investigations on the diseases of vegetables and fruits in Delhi markets have revealed the prevalence of five diseases viz. watery rot and soft rot of potatoes (*Rhizoctonia* sp. and *Rhizopus arrhizus*, respectively); stem rot of cucumber (*Rhizopus nodosus*); Macrophoma rot of mango (*Macrophoma mangiferae*) and stem rot of banana (*Rhizopus oryzae*). Two other diseases viz. stem-end rot of mandarin oranges (*Diplodia natalensis*) and pink rot of apples (*Trichothecium roseum*), have been observed. In addition, occurrence of *Aspergillus nidulans* (conidial and perithecial stage) on banana has been reported.

(f) *Cercospora leaf-spot of grape-vine (Cercospora viticola (Ces.) Sacc.)*.—Further studies on *Cercospora* leaf spot of grape-vine have revealed the presence of pectinase inhibitor in the grape-vine leaves. The inhibitor from two New Zealand varieties, Golden Chasselas and Concord, which are immune to this disease, was most effective while that from highly susceptible variety, Anab-e-Shahi, was least effective. The inhibitor is non-specific, stable to boiling, and is destroyed when autoclaved at 15 lb. pressure for 15 minutes.

13. Nematodes in Relation to Plant Diseases :

Root Knot.—Three important vegetable crops, viz., *bindi*, brinjal and tomato, were found to be affected with root-knot nematodes. Three pathogenic isolates, namely, *Meloidogyne incognita incognita*, *M. incognita acrita* and *M. javanica javanica*, were obtained from the diseased plants. Formation of giant cells was observed, in the roots of tomato,

brinjal and luffa gourd infected with *M. javanica javanica*. The optimum temperature for the hatching of eggs of *M. javanica javanica* was found to be 30°C. and for *M. incognita incognita* 25°C. Both the species were similar with regard to pH tolerance, the hatching being best at pH 7.0 in both. In the case of *M. javanica javanica*, darkness and aeration promoted hatching of eggs. Tomato and groundnut root diffusates resulted in increased hatching, whereas pea and cowpea diffusates inhibited it. Tomato, a susceptible host, showed strong attraction for larvae. Chilli and groundnut were found to be resistant to *M. javanica javanica*.

Tundu disease of wheat.—*Tundu* symptoms were observed in all the sowings done at weekly intervals, starting from 2nd week of October and continued upto 3rd week of December. The ear-cockle symptoms did not appear in any of the sowings done after the first week of November. In the sowing done on 23-10-60, 16.3% of ear-cockle infection was obtained.

It was further observed that when only nematode larvae were introduced in soil, irrespective of the fact whether they were surface sterilised or not, no *tundu* symptoms developed and all the diseased ears showed symptoms of ear-cockle. On the other hand, when galls as such were put in the soil, 14% of the ears showed *tundu* and only 2% showed ear-cockle.

B. SECTION OF PLANT BACTERIOLOGY

14. Bacterial leaf spot of crucifers (*Xanthomonas campestris* var. *armoraciae* (McCulloch) Starr and Burkh) :

The disease could be readily reproduced when adult plants of cabbage and cauliflower were inoculated with a young culture of the bacterium. Infection occurred mainly through hydathodes, and to some extent through the stomata. In addition to cabbage and cauliflower, the bacterium infected turnip, radish and French bean. The disease has been recorded for the first time in the country.

15. Role of bacteriophages in the identification, survival and control of *Xanthomonas citri* :

The biological and physical properties of the two phage isolates, obtained from diseased citrus leaves and from soil underneath the citrus trees, were studied. It was found that the phage did not have any apparent effect on the survival of *X. citri* in sterilised soil.

16. Red Stripe of Sugarcane :

Isolations were again attempted from a large number of specimens from different localities and cane varieties but no pathogenic bacterium could be isolated. From one collection (Co. 312 from Gurdaspur, Punjab) a yellow type (*Xanthomonas* sp.) of bacterium was obtained.

17. Bacterial Blight of Guar :

A bacterial disease causing severe leaf-spot and leaf and stem-blight of Guar (*Cyamopsis tetragonoloba*) was observed in the I.A.R.I. crop during August, 1961.

18. Bacterial Blight of Sesamum :

On the basis of morphological, cultural and biochemical studies, the causal organism has been identified as *Xanthomonas sesami* Sabet and Dowson, which is reported for the first time from India.

[map 298]

C. SECTION OF PLANT VIRUSES

19. Sesamum (*Sesamum Orientale* L.):

Phyllody.—The virus was successfully transmitted to *Crotalaria amagyroides*, *C. walkeri*, *Oxalis corniculata* and *Amaranthus* sp. through viruliferous jassid, *Deltocephalus* sp., which has been reidentified as *Orosius* sp. In the varietal resistance tests, sesamum varieties E.C. 13536, E.C. 13575, E.C. 14534, E.C. 14535 and E.C. 14538 were found to be susceptible to the disease.

20. Sugarcane (*Saccharum officinarum* L.) :

(a) *Mosaic*.—A mosaic culture obtained from the cane variety Co. 951 from Suratgarh Farm (Rajasthan), which produces severe symptoms, is being studied for the identification of the strain of the virus.

(b) *Grassy shoot*.—The virus was found to be uniformly distributed in all the nodes of apparently healthy canes showing symptoms of grassy shoot virus at the lower most nodes. In the host-range studies the virus was transmitted to *Saccharum barberi*, *S. sinensis*, *S. arundinaceum* and *Pennisetum purpureum* var. Thick. *Andropogon halepensis*, *Zea mays*, *Cynodon dactylon* and *Panicum maxicum* var. Silk acted as symptomless carriers of the virus.

21. Sannhemp (*Crotalaria juncea* L.) :

Extracts of 30 different species of plants were tested for their inhibitory activity on the sannhemp mosaic virus. Leaf extracts of *Capsicum annum*, *Datura stramonium*, *Beta vulgaris* and *Raphanus sativus* showed strong inhibition of the virus. The inhibitors in *Beta vulgaris* and *Datura stramonium* were heat-labile, resisted desiccation for one week and were unaffected by dialysis. They, however, lost their activity appreciably on storage for 72 hours and were rendered completely ineffective on dilution of the extracts to 1:175 and 1:100, respectively. The inhibitor in *Capsicum annum* was heat-stable, resisted ageing *in vitro* for 72 hours and desiccation for one week and did not pass through a cellophane membrane. The inhibitory activity was only slightly reduced on dilution to 1:150.

The virus in the standard extract was almost completely inhibited with a gamma radiation dose of 3,00,000 roentgens whereas an exposure for one hour to ultraviolet rays (80 m.u.d.) inactivated the virus in the standard extract diluted to 1:10.

22. Cardamom (*Amomum subulatum* Roxb.) :

(a) "*Chirke*" disease.—Studies on the host range and virus-vector relationship were in progress as also the control of the disease by heat treatment of chirke affected rhizomes.

(b) "*Foorkey*" disease.—The virus could not be transmitted to *Curcuma longa* and Ginger (*Zingiber officinale*) through the aphid vector, *Pentalonia nigronervosa*.

23. Papaya (*Carcica papaya* L.) :

Mosaic.—The Sabour strain of Papaya mosaic virus was found to have the physical properties similar to those of the standard virus except that it produces comparatively severe symptoms. Search for the occurrence of the virus in nature on other hosts has so far not been successful.

24. Banana (*Musa sapientum* L.) :

Mosaic.—The virus does not remain viable in banana leaves dried at room temperature or at 6°C. The virus was transmitted to *Phaseolus vulgaris*, cowpea and cucumber by the aphid vector, *Aphis gossypii*.

25. Mango (*Mangifera indica* L.) :

Malformation.—It has been confirmed that the disease is caused by an eriophyid mite and not by a virus as it could be reproduced in healthy mango seedlings with eriophyid mites collected from apparently healthy mango shoots.

26. Citrus (*Citrus* spp.) :

“Decline” disease.—The Coorg orange trees as well as the suspected grape-fruit trees in Poona when indexed on Kagzi lime were found to be affected with Tristeza virus. The reaction of the virus on seedlings of Gajanimma, China Hazara, Sweet lime, Rangpur lime and Wood apple is being studied.

27. Temperate fruits :

Sixteen important varieties of apple were found to be susceptible to the apple mosaic virus. The virus was also transmitted to peach and plum and appears to be related to the plum “line-pattern” virus. Apricot “oak-leaf” was also found to be induced by a strain of plum “line-pattern” virus. Fig mosaic was transmitted to *Ficus nemoralis*, and an eriophyid mite has been established to be the vector.

28. Vegetable crops :

The viruses causing mosaic and filiformity of leaves in vegetable marrow (*Cucurbita pepo*) were being studied. The virus causing mosaic type symptoms was transmitted by *Myzus persicae*, *Aphis gossypii*, *A. craccivora*, *A. evonymi* and *Rhipidopalpa foveicollis*, has a wide host-range and was identified as a strain of *Cucumis virus* 1. The one causing filiform type symptoms was transmitted by *Myzus persicae*, has its host range restricted to cucurbitaceae and was identified as *Cucumis virus* 3. Pea mosaic virus was found to be sap-transmissible to *Pisum sativum* sweet pea, broadbean, and methi. Brinjal “little leaf” virus was transmitted to *Solanum xanthocarpum*, *S. khasianum* and *S. sisymbirifolium*.

29. Development of new strains, serological relationships and cross-immunity studies :

The antiserum of the bottle-gourd mosaic virus gave precipitate with tobacco mosaic, Dolichos enation mosaic and sunnhemp mosaic viruses indicating thereby their inter-relationship; but no precipitate was obtained with the chilli mosaic virus or *Cucumis virus* 1.

30. Virus-vector Relationships :

The minimum acquisition feeding period for the jassid, *Eutettix phycitis*, vector of brinjal “little leaf”, and *Pentalonia nigronervosa*, vector of ‘Foorkey’ disease of large cardamom, was found to be 10 minutes and the viruliferous vectors transmitted the respective viruses to healthy plants in a minimum feeding period of 15 minutes. The ‘Foorkey’ virus requires a minimum incubation period of 4 hours in the vector and the viruliferous aphids were found to retain the virus for 7 days. Fasting for two to three hours was found to improve the efficiency of the aphid vector, *Longiunguis sacchari*, to transmit the “grassy shoot” disease of sugarcane. *Toxoptera citricidus* adults could acquire the tristeza virus after feeding for 3 minutes on infection-source and transmit it in 5 minutes feeding

to healthy plants. The minimum time required by jassid vector, *Perigrinus maidis*, to acquire the chlorosis virus from diseased jowar plants was found to be 1 hour and the viruliferous jassids could transmit the virus to healthy plants after feeding for 15 minutes. The broadbean mosaic virus was found to persist in the vector, *Aphis craccivora*, for 4 hours at 4-6°C, for 2 hours at 17-22°C and for half an hour only at 35°C.

31. Direct Measures of Control :

Line-pattern affected plum plants and mosaic affected apple plants in pots, kept at $36 \pm 3^\circ\text{C}$ for about 4 weeks, recovered from the respective virus diseases.

Indication of the binjal "little leaf" virus being inactivated in viruliferous jassids when exposed for 24 hours at 40°C has been obtained.

32. General :

Three distinct virus diseases of groundnut *i.e.*, rosette, chlorosis and ring mottle, have been established at Poona. The chlorosis is both juice as well as aphid transmitted whereas the other two are transmitted by grafting only. Mosaic of mulberry was transmitted by *Rhopalosiphum maidis*. Host range studies on *Dolichos enation* mosaic, bean mosaic, yellow vein mosaic of *Eclipta alba* and tobacco leaf curl viruses were continued. Mosaic of Suran (*Amorphophallus* sp.) was transmitted by *Myzus persicae*. Mosaic of *Phaseolus vulgaris* was transmitted by mechanical juice inoculation, through seed as well as by *Aphis gossypii* and *A. craccivora*. Onion mosaic was transmitted through diseased bulbs as well as by *Myzus persicae*, *Aphis gossypii*, *A. craccivora*, *A. evonymi* and the cabbage aphid. Chlorosis of Jowar was transmitted to *Pennisetum purpureum* var. Thick, *Panicum antidotale*, *Canna indica*, *Saccharum officinarum* and *S. arundinaceum*.

D. SECTION OF SYSTEMATIC MYCOLOGY

(i) *New Plant Disease Records*.—Among the pathogenic fungi affecting the economic plants, the following were found to be noteworthy: *Sphaeropsis rosarum* on *Rosa* sp., *Coniothyrium pirinum* and *Mycosphaerella sentina* on *Malus sylvestris*, *Ascochyta lycopersici* on *Lycopersicon esculentum*; *Septoria* sp. on *Oryza sativa*, and *Heterosporium gracile* on *Iris* sp.

(ii) *Hyphomycetes*.—A large number of dematiaceous hyphomycetes were collected, which yielded a number of new species and new records. In the genus *Sporidesmium*, one species, *viz.* *S. indicum*, was found to be new. Seven other species of this genus were found to be new records for India.

In the genus *Corynespora*, one species, *C. indica* and one variety of *C. gigaspora*, *viz.*, *C. gigaspora* var. *microspora*, were found to be new. *Corynespora smithii* and *C. gigaspora* are new records, whereas *C. cassicola* has been found on 5 new hosts *viz.*, *Adhatoda vesica*, *Barleria cristata*, *Carissa* sp., *Glycine max* and *Pycnanthemum* sp. One new species each of *Gonatobotryum* and *Brachysporiella* *viz.*, *G. indicum* and *B. indica*, was also described. Other new records include *Arthrobotryum stilboideum* on dead wood; *Tetraploa aristata* and *T. ellisii* on dead gramineae; *Phragmotrichum chailletii* on *Picea smithiana*; *Cryptocoryneum condensatum* and *Helicosporium lumbricoides* on dead wood. Genera *Brachysporiella*, *Tetraploa*, *Phragmotrichum* and *Cryptocoryneum* have not been recorded from India so far.

(iii) *Genus Cercospora*.—Cataloguing of the species of this genus recorded in India was completed. Critical studies of this group have led to some interesting records. Three new species, *viz.*, *Cercospora holmskioldiae* on *Holmskioldia sanguinea*; *Cercospora kigeliae* on *Kigelia pinnata*; and *C. sterculiae* on *Sterculia platanifolia* have been recorded. In addition, the following new records were made: *Cercospora cassicola* on *Cassia sumatrana*; *C. cestri parqui* on *Cestrum parqui*; *C. erythrinae* on *Erythrina indica*; *C. gossypina* on *Gossypium thurberi*.

(iv) *Genus Septoria*.—A list of Indian species belonging to the genus was completed and the Type specimens of several species were obtained from abroad for comparison.

(v) *Meliolales*.—A list of Meliolales occurring in India was completed. Original descriptions of a large number of species has been collected and compiled. *Meliola* sp. on *Cymbopogon nardus* is a new record for India. A sooty mold on *Crataegus crenulata* collected from Ranikhet has been found to belong to the genus *Irenopsis*.

(vi) *Miscellaneous Indian Fungi*.—Some noteworthy miscellaneous fungi collected and studied include *Plenotrichum* sp. on *Castanopsis tribuloides* ; *Acrosporum* sp. on *Salin* sp. ; *Urosporella* sp. on *Musa sapientum* ; *Nectria coccinea* on *Morus alba* ; *Peronospora alta* on *Plantago* sp. ; *Tassia laurina* on *Berberis* sp. ; *Polystigma* sp. on *Embellia* sp. ; *Urocystis agropyri* on *Agropyron semicostatum*.

The rust of *Cymbopogon nardus* proved interesting. It differs from *Puccinia nakani-shikii* recorded on *Cymbopogon coloratus* in having much narrower and longer teleutospores with very long stalks as compared to the parent species. It has, therefore, been established as a subspecies.

(vii) *Fungal Flora of Delhi*.—Of the 184 fungal specimens collected locally, 6 proved to be new records.

Herbarium :

In all, 400 mycological specimens were added to the Herbarium during the year, bringing the total number of accessions to 27,502. Necessary nomenclatural changes were incorporated in the Herbarium Sheets.

About 50 mycological specimens including several Type specimens were supplied to various research workers in the country and abroad. Indices in respect of world literature on Taxonomy of Fungi and the list of specimens available in the Herbarium were being compiled.

Indian Type Culture Collection :

The total number of fungal and bacterial cultures in the collection now is 1,117. In addition, 61 cultures of rusts and 55 of plant viruses were being maintained. A large number of cultures were supplied to scientific workers and institutes as also to commercial concerns in the country and abroad at their request.

PROGRAMME OF WORK FOR 1962

(A) Plant Pathology :

- (i) Studies on loose smut of wheat and barley, grain smut of *jowar*, bunts of wheat.
- (ii) Determination of physiologic races of *Puccinia graminis tritici*, *P. triticea*, *P. glumarum*, *P. sorghi*, *P. hordei* *Melampsora lini*, *Ustilago tritici*, *Tilletia foetida*, *T. caries*, *Neovossia indica* and *Colletotrichum falcatum*.
- (iii) Studies on rusts of wheat, barley, sugarcane and linseed, Green-ear disease of *bajra*.
- (iv) Factors affecting variation in *Colletotrichum falcatum* and recurrence of red rot epidemics ; origin of new strains of *C. falcatum*.

- (v) Yellow ear-rot of wheat ; stalk and ear-rot of maize ; red-stripe of sugarcane ; citrus canker, study of bacteriophages.
- (vi) Nematode diseases ; microorganism-nematode associations ; 'Molya' disease of wheat and barley ; "Stubby root" of sugarcane ; root-knot of vegetable crops.
- (vii) Screening of varieties of crop plants for their resistance to diseases, particularly rusts and smuts of wheat and barley ; bunts of wheat ; linseed rust ; pigeon-pea wilt and grain smut of *jowar* ; red-rot, smut and rust of sugarcane.
- (viii) Microbial antagonism and antibiotics ; physiology of parasitism and of fungi ; factors affecting virulence of isolates of *C. falcatum*. Effect of ionizing radiations on Plant Pathogenic Fungi and Viruses.
- (ix) Efficacy of different seed-dressing fungicides ; laboratory, pot-culture and field-testing of proprietary fungicides and new compounds ; chemotherapy.
- (x) Study of ecto- and endo-phytic fungal flora of stored seeds and formulation of purity standards for freedom from diseases.
- (xi) Study of the imported seed and other plant material to safeguard against the introduction of any parasitic fungi, bacteria or viruses.
- (xii) Assessment of losses due to certain crop diseases with particular reference to groundnut mosaic, linseed rust, angular leaf spot of cotton, *Helminthosporium* blight of maize, etc.

(B) *Plant Viruses :*

- (i) Mosaic diseases of sugarcane, banana, papaya, brinjal, chilli, groundnut, plum, *Rubus ellipticus* and apple ; line-pattern of plum ; yellow-vein of *bhindi* ; etc.
- (ii) Phyllody of sesamum and other oilseed crops as also of *Brassica* spp.
- (iii) Necrosis of tomato ; "Foorkey" and "Chirke" diseases of large cardamom ; "grassy-shoot" of sugarcane ; sterility disease of pigeon-pea ; small-leaf disease of cotton ; mango malformation ; virus diseases of citrus.
- (iv) Virus-vector relationships of sesamum phyllody, banana mosaic, "grassy-shoot" of sugarcane and "Foorkey" disease of large cardamom.
- (v) Purification of viruses ; studies of properties of purified preparations ; development of new strains and cross-protection tests, serological studies.
- (vi) Control of sesamum phyllody and leaf curl of tomato, papaya mosaic, "grassy-shoot" of sugarcane. Screening of varieties for their reaction to different viruses and location of sources of resistance.

(C) *Systematic Mycology :*

- (i) Taxonomic study of new and unidentified collections ; preparation of exsiccati sets ; list of fungi deposited in the Herbarium and card-indices of species of fungi represented in India. Study of Fungal Flora of Delhi ; taxonomic studies of Hyphomycetes, Meliolales, Erysiphales, *Alternaria*, *Cercospora* and *Nectria* ; and maintenance of host index of fungi.
- (ii) Maintenance of Indian Type Culture Collection of microorganisms and their history sheets ; study of methods for preservation of fungi, bacteria and viruses.

DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

(Dr. C. Dakshinamurti)

A. AGRICULTURAL CHEMISTRY

(a) Soil Fertility :

(1) **Fertilizer Value of Dicalcium phosphate on wheat and maize on acidic soils of Wellington.**—Dicalcium phosphate was found to give slightly inferior yields as compared to superphosphate on the neutral soils of Delhi State particularly for wheat crop. An experiment to test the efficiency of this fertilizer was done on the acidic soils of Wellington with wheat N.P. 200 (a locally bred variety suitable for hills). Dicalcium phosphate gave slightly inferior yield as compared to ammonium phosphate and superphosphate.

(2) **Diammonium phosphate as a fertilizer on paddy and wheat.**—Diammonium phosphate (21% nitrogen and 54% P_2O_5) was tested on paddy in *Kharif* 1960 and on wheat in *Rabi* 1960-61. Paddy and wheat showed significantly higher yields as compared to 'no manure' both in the case of diammonium phosphate and mixture of ammonium sulphate and superphosphate at the rate of 40 lbs. of N and 108 lbs. of P_2O_5 per acre. Yield figures further indicate that diammonium phosphate where P_2O_5 is in combination with ammonia is in no way superior to monocalcium phosphate. Secondly, the high amount of P_2O_5 present in diammonium phosphate would involve waste of P_2O_5 as the mixture of ammonium sulphate and diammonium phosphate at the rate of 40 lbs. nitrogen and 40 lbs. P_2O_5 gave equally good yield as compared to diammonium phosphate.

(3) **Fertilizer value of ammonium chloride with reference to the effect of sodium chloride impurity on plant growth.**—Wheat crop (N.P. 718) and paddy crop (N.P. 130) were raised during the *Rabi* 1960-61 and *Kharif* 1961.

The results showed that the application of sodium chloride and sodium sulphate even at the rate of 285 lbs. of Na_2O did not have any bad effects on crop yields both in the case of wheat and paddy. This indicated that the continuous application of ammonium chloride which contains 2% sodium chloride as impurity will not have any bad effect upon crop yields.

(4) **Gobar Gas Plant.**—The combustible mixture of gases obtained from the Gobar Gas Plant has been found to be suitable for use to operate petrol engines and the power can be utilized for generating electricity, pumping water or doing any other work. The consumption of gas worked out to about 50 c.ft. per hour for a 5 H.P. engine pumping a 2 inch discharge of water.

(5) **Manurial value and efficiency of the slurry from the Cow Dung Gas Plant.**—Pot culture experiments have been carried out to see how the digested slurry coming out of the cow dung gas plant, after anaerobic digestion, compares with the manurial efficiency of farm yard manure, oil cake and ammonium sulphate.

In the case of paddy and wheat, significantly increased yields over no manure were obtained both with the air dried slurry from the cow dung gas plant and farm yard manure. The differences in yields amongst these two treatments were not significant. It was also observed from the yield data that the slurry if applied directly to the soil in the wet condition as it comes out of the gas plant is definitely inferior to the dried slurry and F.Y.M.

The soil binding character of the slurry from the gas plant is also not affected due to the anaerobic decomposition and gas production of the cow dung.

(6) **Manurial value of compost digested with superphosphate.**—In crop tests carried out on wheat, berseem and cowpea with a sample of superphosphate digested compost, received from a big fertilizer concern in the country, no beneficial effects on crop yields and uptake of nutrients were observed in comparison to what were noted with a sample of wellrotten farm yard manure from the I.A.R.I. farm. Although the compost was quite normal in nitrogen content and contained over $1\frac{1}{2}$ times of total P_2O_5 as compared to F.Y.M. still its efficiency was low. It was further observed that the superphosphate digested compost not only carried a lower percentage of humified organic matter but also the fractions of the organic and inorganic phosphorus that could be extracted by the various extracting media were much lower in comparison to F.Y.M., which apparently were responsible for its lower efficiency. It appears that unless the compost is of better quality, phosphating only increases the total P content of the material, most of which may not be available to plants. Thus, there seems to be a necessity to develop some sort of suitable tests by which the phosphate availability of bulky organic manures, especially when they are enriched with phosphate, can be ascertained.

(b) Soil Microbiology :

(7) **Rhizosphere effects on microorganisms.**—The relative preponderance of the microorganisms of different nutritional requirements in the rhizosphere of wheat and control soil at two stages of crop growth were studied. The rhizosphere recorded a significantly higher total bacterial counts, *Azotobacter* population and vitamin B_{12} synthesising organisms than the control soil. A large percentage of vitamin B_{12} synthesisers were from the amino acid requiring group. The rhizosphere supported a higher percentage of microflora requiring amino acids at the flowering stage. The percentage of organisms requiring complex growth factors were more in the control soil than in the rhizosphere.

Azotobacter synthesised very little amount of vitamin B_{12} compared to rhizobium. Among the *Rhizobium* those of berseem and soyabean synthesised more vitamin B_{12} than cowpea and pea. *Azotobacter* isolates from the rhizosphere fixed more nitrogen than those from the control soil.

(8) **Studies on the Rhizobium of some commonly cultivated legumes.**—Highly positive and significant correlations were obtained between glucose consumption and phosphorus utilisation by the *Rhizobium* and its efficiency of nitrogen fixation in symbiosis with host legume. While studying the nitrogen requirements of these isolates in artificial cultures, high positive correlation between nitrogen requirement in cultures and efficiency of nitrogen fixation in association with pea, fenugreek and black gram plants was observed but not in the case of Egyptian beans.

(9) **Bacterisation Experiments.**—(A) *Phosphobacterin*.—Phosphorus solubilising organisms from the U. S. S. R. in the form of phosphobacterin, a bacterial fertiliser and a strain isolated in this country were tried in pot and field trials. It was observed that when a basal dressing of farm yard manure was applied, seed treatment with these organisms increased the crop yields in some cases by releasing more phosphorus from the soil or from the added phosphatic fertilizers. The crops studied were berseem, wheat, maize, paddy, urid and soyabean and the experiments were conducted at Delhi, Karnal, Indore, Nagpur, Palampur and Ranchi. In 10 out of 17 field trials, significant increases in the crop yields due to seed inoculation with phosphobacterin were obtained. In some of the cases, where no response was obtained the soil contained high amount of available P_2O_5 . Different strains of organisms that solubilise tricalcium phosphate were isolated from the rhizosphere of wheat crop.

(B) *Azotobacter* and algae.—In pot culture trials conducted for two years, *Azotobacter* increased the wheat yields significantly. In three years field trials conducted at Delhi in collaboration with the Division of Agronomy, it was observed that though the

in creases varied between 13 to 17%, these increases were not statistically significant. In the case of peas, increase in yield due to *Azotobacter* inoculation was significant in one year out of three years.

In the case of paddy, field trials conducted at the Central Rice Research Institute, Cuttack showed a significant increase in yield due to *Azotobacter* inoculation in the up-land.

Pot culture experiments at Delhi with algae and *Azotobacter* showed that the yield of paddy increased with algae (*Tolypotrix*) when the seedlings were raised on unmanured seed bed, but not when seed bed was heavily manured.

B. PHYSICAL CHEMISTRY

(10) Effect of additions of Bentonite on the productivity of Delhi soils.—

The field experiments done in collaboration with Agronomy Division have confirmed earlier pot-culture experiments in showing a great scope for the application of bentonite to the Delhi soil. Bentonite @ 6 tons/acre increased the yield of wheat by 38% while F.Y.M.+Bentonite increased it by 34% compared to that of the untreated plots. In the pot culture experiments significant residual effects were, however, obtained for the treatment of 6 tons bentonite+F.Y.M. @ 3 tons per acre.

(11) The Thermodynamics of Flocculation of clay minerals sodiumised to varying extents.—The energy required for the flocculation by electrolytes of the various clay-minerals sodiumised to varying extents was found to be of the order of 107.7 cal. for kaolinite, 122.1 cal. for illite and 120.3 cal. for montmorillonite from sols of about 0.5% strength. The energy required for dispersion of montmorillonite, however, appeared to be 190.3 cal. At 2.5 m.e./litre salinity, there is rapid increase in the degree of dispersion of montmorillonite with S.A.R. of the equilibrium solution up to about a value of about 10 above which the degree of dispersion increased only relatively slowly to values greater than 83%.

(12) The Thermodynamics of Plant absorption of Phosphorus.—The equilibrium phosphate potential of young paddy plants grown in sand culture was 7.20. When, however, active transport was stopped with sodium azide, this value became 6.05. From this it can be estimated that the free energy decrease caused by active transport is of the order of 1.22 kilo calories per equivalent of monocalcium phosphate absorbed by the plant. With increasing phosphate in the culture solution or lower values of phosphate potential in the solution, all the plants studied (Maize, paddy, wheat, tobacco and *mung*) showed lower values for their equilibrium phosphate potential upto about a value of 5.2 for the former, below which the equilibrium phosphate potential of the plants tended to remain constant.

(13) The Physical Chemistry of Soil Potassium and its availability.—

In the course of preliminary pot culture experiments on wheat with mixtures of the Delhi soil and Jamuna sand, the optimum value for the K. A. R. of the soil was found to be of the order of 0.278×10^2 in all mixtures excepting the highly sandy mixture containing 25% soil. The K. A. R. of wheat found from sand culture experiments earlier was 0.308×10^2 which is close to the above optimum value as required by the thermodynamic theory of the availability of soil potassium to plants.

(14) The Reclamation of Saline-Alkali soils of Pusa and Karnal.—The reclamation trials of the soils of the N. D. R. I., Karnal in block No. 7 have been started on the basis of experience gained with earlier trials conducted in the Outer Mushar field at the B. S. S., Pusa. These trials would show the relative usefulness of—(1) leaching, (2) gypsum and leaching, (3) gypsum and leaching with closer spacing of open drains, and (4) vertical organic mulches and gypsum and leaching with closer spacing of open drains. Preliminary observations have shown that the water table is considerably lowered under treatment No. 4 after a year of application of these measures.

C. SOIL SURVEY AND SOIL PHYSICS

(15) **Soil Genesis.**—(a) *Black and associated soils.*—Investigations on the genesis of catenary soils in Durg district of the Chhatisgarh basin (Madhya Pradesh) was completed. The catena consists of black, brown, yellowish and red soils in toposequence on Cuddapah and Vindhyan formations composed of sandstone, clay shales and limestone. But the parent material of the soils appears to be similar as evidenced from the uniform petrographic composition of the fine sand fractions which differs only in relative proportions of the minerals. Alteration of orthoclase feldspars decreases down the slope *pari passu* with decrease in drainage condition. Persistence of resistant minerals—magnetite, zircon and tourmaline and absence of weatherable minerals throughout the sequence indicates that the soils were formed from pre-weathered rock. The upper slope members (red and yellowish soils) are more weathered than the lower slope members.

(b) *Alluvial soils.*—The soil profiles studied at Hardwar and Bahadarabad in the Upper Ganges Valley were characterised more by stratification and to a less extent by pedogenic horizonation, thereby indicating the young and immature nature of these soils. The soils are slightly acidic to neutral in reaction, low in C/N ratio (4 to 6). Bahadarabad soils are higher in c.e.c. (14 to 31 m.e./100 gm.) as compared to Hardwar soils (3.3 to 7.7 m.e./100 gm.). Accumulation of clay and bases at a certain depth of the profiles, probably forming 'B' horizon, indicates that soil forming processes are active in the soil region. High c.e.c., silica-sesquioxide ratio (2.29 to 2.55), and potash (2.7 to 3.6%) are indicative of the illitic nature of clay mineral.

(c) *Desert soil.*—Characteristics and genesis of desert soils, collected from Pali, Nagour, Jodhpur, Barmer and Gadra Road of Rajasthan receiving varying amount of rainfall, are being investigated. The soils are deep and of coarse texture. The soils of the lower rainfall are a (*i.e.* formed under more arid conditions) are more siliceous and less sesquioxidic than those of the area of comparatively higher rainfall condition. Variations in the chemical constituents are as follows : Silica—44.17 to 79.87% ; sesquioxide—10.63 to 17.95% ; calcium oxide—2.60 to 10.07 ; magnesium oxide—1.70 to 3.76%.

(d) *Red and associated soils.*—Genesis of red and associated black soils in Rudrur (Andhra Pradesh), developed on dolerite and granite-gneissic parent rock is investigated. Red soils are formed under well drained conditions, whereas the associated black soils under impeded drainage conditions. The mineralogical make up of the fine sand fractions bears a close relationship to the rocks mentioned above. The soil forming process, from the rock to the soil through the parent material, appears to be loss of sesquioxide and consequent enrichment in silica and this process is intensified with distance from the seat of weathering of the parent rock. The high cation exchange capacity and chemical composition of the clay fractions indicate besides kaolinite and illite, some other clay mineral.

(16) **Mineralogical Studies of Soils and Clays.**—(a) *Primary minerals.*—Black and red soils existing side by side, were observed to be formed from two principal types of underlying bedrocks—charnockites, weathered granites and granite-gneiss. Feldspars (orthoclase dominating over plagioclase) and quartz constituted the bulk (94 to 97%) of the fine sand fraction of the soils while the heavy mineral assemblage consisted of hypersthene, hornblende, biotite, tourmaline, zircon, garnet in the decreasing order of abundance and the assemblage indicates the influence of both the bed-rocks mentioned above. Charnockites and granites appear to be present intimately mixed in the field, particularly in the valleys. Thus, under the prevailing environmental conditions, the parent material has played a dominant role in the formation of these diverse types of soils. This observation is further corroborated by a similar observation of red and black soils in toposequence in Rudrur (Andhra Pradesh), where the underlying bed-rocks were dolerite and granite-gneiss in stratigraphical position.

The still more dominating influence of parent rocks on the mineralogy of soils was observed in the case of sedentary black soils formed from trap rocks, in Bombay and Poona, which are rich in plagioclase feldspars, pyroxenes, olivines, and iron ores in the decreasing order of abundance.

(b) *Clay minerals*.—Genesis of clay minerals in the soil clays was observed to have a definite relation to primary minerals in the silt and fine sand fractions of contiguous red and black soils from Coimbatore. Clay fractions isolated from both the soils were dominantly montmorillonitic with traces of illite and kaolinite and were associated with low quartz/feldspar ratio in the silt fraction along with unaltered or partially altered orthoclase and plagioclase feldspars, pyroxenes and amphiboles in the fine sand fraction. Partial hydrolysis of feldspars particularly of orthoclase feldspars in the silt and sand fraction results in the formation of mica and illite whereas that of the plagioclase feldspars and amphibole-pyroxene groups leads to the formation of montmorillonite.

In another study on the degradation of minerals in soil clays, it is observed that ethylene glycol retention and internal surface area of clays increased *pari passu* with the degradation of the clay minerals as indicated by the broadening of the X-ray diffraction lines.

(17) **Studies on Soil Structure**.—(a) *Effect of fertilizers and manures on the structure and other physical properties of soils*.—Pot cultures experiments in the Soil Fertility Section are carried out to study the effect of cowdung slurry (dry and wet), F.Y.M. on the yield of wheat. The soils from these trials were tested for the water stable aggregates. The soils were better aggregated in the cowdung slurry (both wet and dry) treatment as compared to control and the treatment with ammonium sulphate and the difference was significant. Percentages of aggregates greater than 0.25 mm. were 46.6 in the former and 31.6 in the latter.

Cattle manure and phosphate treated plots in the Permanent Manurial Experiment Plots (Western series) showed the higher percentages of water stable aggregates as compared to the control and other treatments. This observation is similar to that in the case of the other series. Similarly, in the Permanent Manurial Series at Pusa (Bihar) the soils in the plots treated with farm yard manure showed higher permeability as compared to the soils treated with inorganic fertilizers.

(b) *Effect of soil conditioners on soil structure*.—Guar seed (germinated, soaked, original—powdered), tamarind seed and Krilium were tested for their power of aggregation in the case of black clay soil from Hosangabad. Powdered guar seed (germinated as well as soaked) was comparable with Krilium in aggregating power. Increase in percentage of aggregates greater than 0.25 mm. over the control was about 15 per cent.

(18) **Studies on Soil Moisture**.—Soil moisture-tension relationships were studied in 48 loamy soils from Karnal (Punjab). Percentages of moisture at pF 2.7 and pF 4.2 varied from 12.1 to 18.1 and 5.8 to 10.8 respectively. The moisture retention capacity was 7.1 per cent on the average. The wilting point determined by the biological method (using sunflower as indicator plant) and by the pressure membrane technique compared well. pF curves differed in the soils from different depths of a profile from Delhi. pF curves were found to be almost straight beyond the range of 11 atmospheres pressure.

(19) **Run-off and Soil Loss Studies**.—The investigation is conducted since 1958 on a sloping land (3.5 per cent sloped) in the Farm area to study the run-off and soil loss under different cropping practices *viz.*, grass (permanent), fallow-bajra, wheat-fallow, and natural vegetation in the four run-off plots. Data are presented for 1961. (Total

rainfall-996 mm.; Total erosive rainfall-806 mm.; number of rainy days-64; number of days of erosive rainfall-28). The soil loss and run-off data are presented below:

Plot No.	Cropping practices	Run-off		Soil loss (tons/acre)
		Cu. ft. acre	Per-centage	
I	Grass (permanent)	28,937	20	0.052
II	Fallow- <i>Bajra</i>	53,778	37	5.918
III	Wheat-Fallow	61,361	43	7.509
IV	Natural vegetation	15,521	10	0.027

Soil loss and run-off were highest in plot III and lowest in plot IV. The minimum intensity of rainfall which caused soil erosion was 0.10 mm./min. which agreed well with previous years' observation. There was significant soil loss and run-off in the plots growing grass and natural vegetation. In plot I, soil loss occurred during May and June when the vegetative growth was poor. The plot III was fallow during the period of maximum rainfall, thereby causing significant and maximum soil erosion. In plot II, the soil loss occurred during this period although the crops were standing. Soil splash was considerably higher in the plots growing *bajra* and wheat as compared to other plots and was more or less dependent on the intensity of rainfall.

D. PLANT CHEMISTRY

(a) Organic Chemistry :

(20) **Pesticides (Synthetic).**—Properties of the substituted acroleins as insecticides were reported last year. Besides, their property as insecticides, preliminary test indicate that 2-n-amy-3-piperonyl acrolein has an activity as synergist for pyrethrins. When tested against adults of *Tribolium castaneum*, 0.02% of pyrethrins alone caused 60.9% kill of the insects, while 0.01% pyrethrins in combination with 0.25% of the compound gave 98% mortality.

(21) **Pesticides (Botanical).**—(a) *Pyrethrum*.—It has been observed that cyclopropane ring in chrysanthemic acids, undergoes apparently theoretical fission on treatment with mercuric acetate-Hanus reagent.

(b) Fatty acids from mustard, groundnut and sesame oils, auto-oxidised by aeration, till iodine value decrease becomes negligible, were tested for their fungicidal activity as potassium salts. The auto oxidised fatty acids, showed slightly lower activity than the original fatty acids.

(c) Extractives from neem seed cake, practically free from fatty oils and acids, have been obtained in about 10-12% yield, it is expected that extractives will have more pronounced a physiological activity as insect repellent and insecticide than reported earlier for the product obtained with hot alcohol.

(22) **Pesticides Residues Hazards.**—In addition to BHC, DDT, aldrin and diel-drin that were investigated for harvest time residues, two more insecticides endrin and malathion were also included. DDT, BHC and Aldrin in the forms of different formulations were studied on tomatoes. Lindane, aldrin and endrin were used in the case of cabbage. Generally the deposits were far greater and the residues lower than the tolerances fixed for these insecticides by the U. S. Food and Drugs Administration,

Translocation of lindane, after two weeks of application as a soil insecticide in maize, cabbage and mustard plant, was noticed. For the dosage 100 mg/pot, translocation in maize was found to be the highest, 2.12 ppm. as compared to 0.35 ppm. in case of cabbage and 1.0 ppm. in case of mustard.

Studies on BHC contamination to peripheral layer of wheat grains stored in different types of jute bags showed that with tightly woven hesian bags, the insect infestation and insecticidal contamination to the grains is much less than with B. Twill type bags commonly used for the storage of grains.

(23) Essential Oils.—(a) 1188 strains of spices—Ajwain, dill, coriander and fennel seeds were examined. Out of 245 samples of ajwain seeds, 7 showed an essential oil content of 5.78-6.08% against an average content of 3.5%; out of 81 strains of dill, 6 showed an oil content of 5.88-6.88% against the average of 3.5%; out of the 466 samples coriander, 23 strains gave an oil yield of 0.46 to 0.96% against an average of 0.12-0.18 in most of the Indian varieties. None of the strains of fennel was found to be outstanding.

(b) In connection with investigations on oleo-resin ex *Pinus longifolia*, it has been observed that the ash and iron content of different grades of rosins, have a linear relationship with colour of the grades. Similar observation was made with respect to the oleo-resin itself.

(b) Biochemistry :

(24) Nutritive value of Indian wheats.—(a) *Protein-efficiency ratio.*—In order to evaluate the nutritional value of Indian wheats, protein-efficiency ratio of twelve important wheats grown at Delhi was determined. The protein-efficiency ratio and the protein contents were found to vary from 1.63 to 1.96 and 10.00 to 13.50 per cent respectively. No relationship was found to exist between the protein-efficiency ratio of these wheats and their protein contents.

(b) *Lysine and methionine content.*—In order to assess the nutritional value, lysine and methionine content of some important Indian wheats were determined by the microbiological method. The content of lysine and methionine varied from 2.93 to 4.23 and 1.95 to 3.03 respectively on 16 gm, nitrogen basis.

(25) Availability of micro-nutrient in soils of Maharashtra State.—Representative soil samples of different types were collected from the Maharashtra State and were analysed for their content of available zinc by the chemical and microbiological methods. The soils included laterite, black, coastal alluvium and were also from certain salt affected areas. The soils varied in pH values of 5.5 to 9.5. The available zinc determined by these methods showed wide variations ranging from 0.93 to 9.06 parts per gram of soil.

(26) Foliar application of Urea on maize.—The efficiency of foliar application of urea as compared to simultaneous application of the same to the soil, was studied with maize plants grown in pots containing sandy loam soils (pH 7.7) of medium fertility status. Nitrogen applied by both the methods increased the nitrogen content of the plant. The uptake of nitrogen was, however, significantly greater from the spray than from the corresponding soil application.

(27) Respiration of wheat seedlings.—Some of the respiratory enzymes, such as succino-oxidase, cytochrome oxidase, ascorbic acid oxidase, malic dehydrogenase were isolated from wheat grain and their kinetics have been studied. The respiration of these tissues was found to be largely resistant to a number of respiratory inhibitors.

(28) **Nutritional requirement of *Derxia gummosa*.**—*Derxia gummosa* was recently isolated in West Bengal from a local soil. It is capable of fixing nitrogen symbiotically. It can utilize a number of sugars. Its growth is inhibited by a number of inhibitors azide, hydroxylamine and arsenite being more inhibitory. It is a heavy producer of gum.

(29) **Amino acid deaminases in *Azotobacter*.**—In the course of studies on the metabolism of *Azotobacter*, threonine was found to be deaminated oxidatively by the washed organism, the optimum pH for the reaction being 7.8. A cell-free preparation, obtained from this organism, strongly deaminated threonine.

(30) **Nitrogen metabolism in *Aspargillus niger*.**—It was observed that in copper deficient cultures, the decrease in protein synthesis resulted in large accumulation of free amino acids, while there was no reduction in the utilization of nitrate. In zinc deficiency the synthesis of protein as well as the reduction of nitrate are considerably reduced. Under copper deficiency there was a large accumulation of riboflavin unlike in zinc deficiency.

E. PHYSICS

(31) **Evaluation of effective rainfall and irrigation from ground-water measurements.**—Analysis of the ground-water data available at the I.A.R.I. from 1940 onwards revealed that about 42.51% of the total rainfall received and 9.11% of the total irrigation applied reach the ground-water level, if surface drainage is neglected. The results clearly indicated the importance of taking effective measures regarding proper surface drainage at the I.A.R.I. farm area as one of the measures to decrease the ground-water level effectively.

(32) **Study of Clay Mineral.**—X-ray and electron microscopic studies on a number of clay minerals obtained from Hyderabad, Mysore and Himachal Pradesh indicated definite presence of nontronite, a clay mineral which could not be distinguished separately from montmorillonite in the earlier studies.

(33) **Spectrophotometric Studies.**—Using the spectrophotometric method standardised in this laboratory, capsaicin content of chillies was estimated in 12 promising N.P. varieties. The capsaicin content ranged from 0.2 to 1.2% of the dried material. A comparison of these values with those recorded in other parts of the world indicates that the highest value recorded in the present investigation is about 50% more than those recorded in foreign countries.

(34) **Electron Microscopic Studies.**—Electron micrographs of several samples of viruses, clays, diatoms were taken during the period to study their submicroscopic structure. In two of the clay samples studied, diatoms were found to be present along with the clay minerals. High specific areas and comparatively low cation exchange capacity of these clays observed may partly be explained as due to the presence of the diatoms. In a few other clay specimens nontronite was found to be present along with other clay minerals. Structure of mucilage of blue green alga *Aulosira fertilissima* Var *tennis* Rao was observed to be cross fibrillar. The microfibrils have a thickness from 110A° to 250A°.

F. SOIL TESTING SERVICE

(35) **Correlation of Crop Responses with Soil Tests in Different Indian Soils.**—Response curves for paddy (var. N.P. 130) to the application of potassium in a large number of our soils were obtained under pot culture conditions, following usual procedures. Soil samples from Karjat, Kalhandi and Varanasi showed good response to potassium over a basal dose of all other nutrients. Percentage yield responses calculated from data on the soils used, were correlated with available potassium extracted by a large

number of methods, representing (a) methods estimating water soluble plus exchangeable, and (b) methods estimating water soluble plus exchangeable plus non-exchangeable potassium. It was observed that the amount of potassium extracted by using different solutions is influenced by the nature of the extractant, details of extraction and the clay type predominantly present. On the basis of correlation study Hunter and Pratt's method using 6 N H_2SO_4 appeared to be the best ($r = -0.6766$ significant at 5% level). In the soils having illite as the dominant clay mineral Barbier and Morgan's method using ammonium acetate at pH 4.8 and Hanway and Heidal's method using neutral normal ammonium acetate gave promising results. In acidic soils, acetic acid extraction and percentage potassium saturation were found to give a better picture of potassium supplying power of soils.

(36) Soil test correlation with Crop Responses in simple fertilizer trials in Cultivators' fields.—Soil samples from a large number of simple fertilizer trials on paddy, maize, *bajra* and wheat in several districts in U.P. sent to I.A.R.I. laboratory were analysed for available nutrients. The results have been correlated with yield responses. In Rampur district highly significant correlation was obtained between available phosphorus and % yield response in paddy ($r = -0.7925$, $n = 16$) and wheat ($r = -0.7504$, $n = 23$). In Muzaffernagar in wheat also significant correlation between available phosphorus and % yield response was obtained ($r = -0.5336$, $n = 24$). In Meerut district both in wheat and *bajra* significant correlations were obtained between available potassium and % yield responses (*Bajra* : $r = -0.7308$, $n = 8$; Wheat: $r = -0.4205$, $n = 24$). In Bulandsahr, Meerut and M. Nagar in Maize significant correlations were obtained with available potassium ($r = -0.6135$, $n = 15$).

(37) Soil tests and fertility conditions.—This study relates to samples drawn from fields under two different systems of farming: vegetable growing and cereal cultivation, on the same soil type *viz.*, sandy loam "Kohi" soil of Mehrauli Block, Delhi State. Under vegetable farming available phosphate content has increased from as low value as 2-6 lbs. P/acre to as high as 38-68 lbs. P/acre. Similarly in the case of available potassium, the increase is remarkable from 136-244 lbs. K/acre to 440-880 lbs. K/acres. Organic matter has increased 2-3 times from the original low values which are under cereal cultivation. The possibility or otherwise of building up of organic matter of tropical soils through incorporation of bulky organic matter is usually debated and questioned. Here is a case where application of organic manures and fertilizers over a decade or so has resulted in building up a higher level of organic matter in the same soil type and under the same climatic conditions but under different systems of farming.

(38) Methods for determination of organic carbon in soils.—A new procedure for determination of organic carbon in soils has been developed and is as follows: Weigh out 1.0 gram of soil (in soils containing more than 1% organic carbon take 0.50 or 0.25 gram) in 100 ml. conical flask, add 10 ml. of 1 N $\text{K}_2\text{Cr}_2\text{O}_7$ solution followed by 20 ml. of conc. H_2SO_4 containing 1.25% Ag_2SO_4 (in case of soil containing chloride). Allow to stand for $\frac{1}{2}$ hour, centrifuge for 5 minutes and measure the green chromous colour of the centrifuged solution in a photoelectric colorimeter using 660 m μ filter. Standard curve is prepared by treating weighed amounts of pure sucrose in the same way. Accuracy and reproducibility of the method has been checked through recovery studies. Results have been compared on a large number of soils collected by Prof. Jenny of the University of California on which organic carbon data were available.

G. RADIOTRACER INVESTIGATIONS

(39) Physico-chemical investigations on Rice Soils using the Tracer technique.—The effect of flooding and organic matter as well as the chemical and physico-chemical changes accompanying them on the availability and utilization of phosphorus by rice on two soils, one from I.A.R.I. farm and the other from West Bengal have been studied. The results have clearly brought out the beneficial effect of submergence and

organic matter on phosphate availability and uptake. The results show (i) paddy plant maintains the soil pH in a definite range during its growth period and the pH change has little influence on Eh change, (ii) organic matter manifests its influence in creating a reducing atmosphere and in solubilising phosphate, (iii) the reducing condition leads to the increase in the concentration of Fe^{++} and NH_3 and exchangeable Mn, and (iv) increasing availability of NH_3 -nitrogen, reduced iron and phosphate leads to higher uptake of phosphorus by the rice plant.

In a study of the effect of silica on rice plant nutrition and on lodging four levels of sodium silicate, 0, 500, 1,000 and 1,500 lbs. per acre were factorially combined with 0, 100, 250 and 500 lbs. nitrogen per acre over a basal dose of 60 lbs. P_2O_5 per acre and 60 lbs. K_2O per acre. Plant samples were analysed at two stages of growth. Analysis of the first stage harvest has shown nitrogen application to increase plant growth, total phosphorus uptake and utilization of applied phosphatic fertilizer markedly. Application of sodium silicate did not influence plant growth, total phosphorus uptake and utilization of applied phosphatic fertilizer. Combined application of nitrogen and silicate was not found to be superior to N alone. A values remained unchanged under both nitrogen and silicate treatments.

In another study it was found that flooding as is usual under paddy culture, of soils which have never grown rice before leads to a great increase in available soil phosphorus and A values.

(40) Effect of degree of soil saturation in respect of cations and anions on utilization of phosphorus by crop.—An attempt has been made through the use of P^{32} to study the effect of phosphate saturation percentage of the soil under various cationic systems on the uptake and utilization of phosphorus by rye in Neubauer's bio-assay method. Soils studied represented Red, Black and Alluvial soil groups. From the results obtained it can be concluded that (i) increase in the degree of phosphate saturation of the soil increases total uptake of phosphorus in all soils, (ii) the effect of cation is interrelated with the degree of phosphate saturation as regards uptake of total phosphorus, (iii) there is a critical level of phosphate saturation depending on cationic system and soil type for optimum uptake of phosphorus, and (iv) at higher levels of phosphate saturation above a certain "critical level" the uptake of fertilizer phosphorus decreases whereas that of soil phosphorus increases irrespective of cationic system for the soil type, the "critical level" being different with different soil type and cationic system.

(41) Investigations on phosphorus fertilization of linseed, potatoes and cotton by radiotracer technique.—Co-operative experiments on linseed were conducted in the Agronomy Division Farm for four seasons, 1957-58, 1958-59, 1959-60 and 1960-61. Plant samples were collected at three stages of growth for determination of total as well as radioactive phosphorus. The data for all the seasons have been statistically analysed. The results show that treatments did not significantly affect the phosphorus composition at any stage of growth in 1957-58, 1958-59 and 1960-61. But in 1959-60 it was observed that treatments D & F (30 lbs. P_2O_5 /acre placed 1" below, and 1" below and $2\frac{1}{2}$ " sideways) significantly superior to others at the first stage; treatment B (30 lbs. P_2O_5 /acre mixed in 2" surface soil) gave the lowest phosphorus uptake. Data on the fraction of phosphorus in plant derived from fertilizer showed that at first stage of growth in all the four seasons treatments E and D (30 lbs. P_2O_5 /acre placed $\frac{3}{4}$ " and 1" below seed respectively) were significantly superior, followed by treatments G and F (30 lbs. P_2O_5 /acre $2\frac{1}{2}$ " sideways and $\frac{3}{4}$ " and 1" below seed respectively) and then C and B (30 lbs. P_2O_5 /acre mixed with 4" and 2" surface soil respectively). At the second and third stages treatments G and F were superior to others. The results while showing the beneficial effects of placement also give an idea about the root growth and distribution pattern of the crop.

(42) Effect of nitrogen on the efficiency of fertilizer phosphorus use.—Greenhouse studies were made on five soils having pH 5.3 to 8.0, using *Kharif* crop *ragi* and *rabi* crop wheat. Percentage uptake of total phosphorus and percentage utilization of fertilizer phosphorus from superphosphate is more than these from dicalcium phosphate in neutral to alkaline soils. In acidic soils dicalcium phosphate proved better. Nitrogen both in the form of urea (NH_4 source) and sodium nitrate (NO_3 source) stimulates the efficiency of the phosphatic fertilizer source. The studies also showed the importance of nutrient elements balance (N, P, K and Ca) in understanding the influence of nitrogen.

(43) Studies on Subsoil nutrient availability to Crops.—Green manuring crops are known to bring up minerals through the root systems from the lower soil horizons. Raising of green manuring crops could result in the uptake of nutrients present in subsoils, and these when buried, affect a transfer of nutrients from subsoil to the surface soil for the benefit of the succeeding cereal crop. The efficiency of different green manure crops to affect such a transfer will naturally vary and the one with the highest efficiency will be more useful in areas deficient in surface soil phosphorus.

Using P^{32} tagged superphosphate, the relative efficiencies of three common green manure crops, namely '*Dhaincha*' (*Sesbania aculeata*), '*Sanhemp*' (*Crotalaria juncea*) and '*guar*' (*Cyanopsis psoraleoides*) to take up tagged phosphate applied in the subsoil depth of 18–25 cm. layers, was determined in three types of soils, namely Delhi (sandy alluvium), Baroach (black medium clay soil, and Karjat (medium black silt loam). '*Dhaincha*' on an average had 77.1% of its phosphorus derived from 18–25 cm. layer and was significantly higher than '*guar*' (52.7%) and '*Sanhemp*' (42.8%). The percentage utilisation of phosphorus placed in the subsoil depth was also the highest in the case of '*Dhaincha*' followed by '*guar*' and '*Sanhemp*'. The amount of applied phosphorus transferred from subsoil depth to surface soil by the above three green manures exhibited similar trends. The above results indicate that it will be possible to select a suitable green manure crop with the highest efficiency for the transfer of nutrients from the subsoil to the surface soil.

(44) Contribution of different soil layers towards the phosphorus nutrition of *Dhaincha* crop.—Studies were conducted in big 30 lb. pots to investigate if there is any differential absorption of phosphate in pots also from the different soil depths although the fertiliser added in all the layers is the same. With *Dhaincha* results indicated that absorption from the second 3" to 6" layer is higher than from the 0–3" layer although the extent of absorption in different layers varied considerably with the soil texture.

(45) Assessment of Crop nutrient status by radiotracer technique.—McAuliffe *et al.* (1948) and Olsen (1953) described a procedure for the estimation of mobile phosphorus in soils using P^{32} equilibration method. As there is now increasing evidence that the absorption of nutrients from the soil by the plant is a reversible reaction attempts have been made to determine the mobile phosphorus in plants by a similar procedure. The values obtained for crop Plants showed that they are nearly constant for the plant and their stage of growth and independent of P concentration used for equilibration with the intact plants. The values were of the order of 0.51 to 0.62% in the case of sorghum and 2.0 to 2.9% in the case of *Dhaincha* (*Sesbania aculeata*) of their total phosphorus.

(46) Evaluation of fertilizer value of Nitric Phosphate.—Keeping in view the prospective use of nitric phosphate in India, the fertilizer value of P^{32} labelled nitric phosphate, dicalcium phosphate and superphosphate prepared from Moroccan rock phosphate was evaluated with wheat crop on two soils (Karnal and Mangalore). On Mangalore soil which is acidic, the nitric phosphate was found to be superior to superphosphate and equal to dicalcium phosphate while in Karnal soil (which is on the alkaline

side), superphosphate gave better results. The utilisation of fertiliser phosphorus applied at 80 lbs. P_2O_5 /acre in the case of nitric phosphate fertilizer was 7.12% as against 4.13% in the case of super and 8.2% in the case of dicalcium phosphate in Mangalore acidic soil while in the case of Karnal soil, the figures were 9.49%, 23.07% and 17.21% with respect to nitric, super and dicalcium phosphate, respectively.

(47) **Phosphate feeding power of plants.**—With a view to studying the complementary influences of grasses and legumes with regard to phosphate sources, combination of oats and berseem was studied in 1960-61 *Rabi* season. From the analysis of the plant samples, it was deduced that oats apparently feed on fertilizer phosphorus preferentially over the soil phosphorus as compared to berseem and the magnitude of difference appears to be affected by the solubility of added fertilizer.

(48) **Studies on phosphorus nutrition of Paddy.**—With a view to exploring the possibility of economising phosphate application to transplanted paddy in fields, the nutritional pattern of phosphate absorption by paddy was studied. Paddy seedlings were enriched with phosphate in the early stages such that further requirements can be minimised. In a trial run, using nutrient solution of 'Kimura' at $\frac{1}{2}$ the dose of nitrogen and twice that of P, a maximum of 15.5 mg. P/gm. plant material was attained in three weeks which subsequently came down to 12.6 mg./g. and 11.8 mg. P/g. during the 5th and 6th week respectively. They were subsequently transplanted and fed on—(1) full P up to tillering, (2) full P up to flowering, (3) $\frac{1}{2}$ dose of P throughout the growth period and (4) no P subsequently. The plants under the treatment without P have shown poor growth, and the yield expected is also low but those under full dose also did not do well. The best dose was found to be $\frac{1}{2}$ dose of P throughout the period. Probably some adverse effect of high P is indicated.

PROGRAMME OF WORK FOR 1962

Soil Fertility :

- (1) Manurial efficiency of the digested slurry from the Cowdung Gas Plant.
- (2) Soil Fertility investigations under long-term manuring and crop rotation practices.
- (3) Manurial efficiency of superphosphate digested compost.
- (4) Fertilizer value of mixed N-P-K granulated fertilizers.
- (5) Studies on available nitrogen in soils.
- (6) Utilisation of waste materials like mahua cake, wool, leather etc. as manures
- (7) Utilization of sea weed as a manure.

Soil Survey and Soil Physics Section

- (1) Genesis of Indian soils : Black alluvial, red and lateritic desert soils.
- (2) Mineralogical studies of soils, clays, and clay minerals in relation to soil development.
- (3) Studies on soil structure.
- (4) pF curves of Indian soils.
- (5) Effect of continuous application of fertilizers and manures on the structure and other physical properties.
- (6) Runoff and soil loss experiments.

Physical Chemistry :

- (1) The reclamation of saline-alkali soils of Pusa and Karnal.
- (2) Studies on the physico-chemical criteria for the suitability of irrigation waters for different soils.
- (3) Effect of the addition of bentonite and clay humus complexes on soil properties and yield of wheat.
- (4) The Physical Chemistry of the availability of phosphates in the soil.
- (5) The Physical Chemistry of the availability of Potassium in the soil.

Organic Chemistry :**(1) Pesticides :**

- (a) Synthetic Pesticides—Synthesis of compounds with different groups, as possible insecticides; synergists for insecticides; fungicides; weedcides and formulation of pesticides.
- (b) Pesticides of Botanical origin.
- (c) Improvements in Pyrethrum and examination of indigenous plant materials for pesticides.
- (d) Persistence of residues and translocation of Insecticides, when applied to food and fodder crops.

(2) Essential Oils :

- (a) Improvement of essential oil yielding spices of India-Ajwain, dill, coriander and fennel.
- (b) Studies on the refining of aleo-resin for obtaining quality rosin and turpentine oil—as raw material for the production of agricultural chemicals.

Bio-Chemistry :

- (1) Quality of Crops as influenced by manurial, cultural and management factors.
- (2) Nitrogen metabolism in the plant.
- (3) Available micro-nutrients in the soil.
- (4) Studies on plant metabolism with radio-isotopes.
- (5) Foliar Application of Nutrients to Crops.

Physics :

- (1) Spectroscopic methods for quantitative estimation of micro and macro-elements
- (2) Qualitative and quantitative estimation of clay minerals by X-ray diffraction studies.
- (3) Absorption spectrophotometric studies of biological compounds.
- (4) Electron Microscopic studies on clays, viruses, algal and plant cell-wall structures.
- (5) Electro-Physiological techniques for studies on insect nerves.

Radiotracer Laboratory :

- (1) Physico Chemical investigations on rice soils using the tracer techniques.
- (2) Degree of cation and anion saturation on utilization of phosphorus by crops.

(3) Spray fertilization on soil application of phosphatic fertilizer on important crops.

(4) Quantitative measurement of radioactivity using autoradiography.

(5) Phosphorous fertilization of cotton, linseed and potatoes (Co-operative experiment with Agronomy Division).

(6) Studies on subsoil nutrient availability to crops.

(7) Phosphate feeding power of plants.

(8) Sulphur status of Indian soils with special reference to paddy.

(9) Liming in relation to the uptake of applied phosphorous by paddy in acid soils.

Soil Testing Laboratory :

(1) Soil Test—Crop response correlation work on phosphorus and potassium.

(2) Salinity test in relation to growth in Delhi soils.

DIVISION OF MICROBIOLOGY

(Dr. C. Dakshinamurti)

A. SOIL MICROBIOLOGY

1. Studies on *Rhizobium* spp. of some common cultivated legumes.—A study of the salt tolerance of the Rhizobial isolates from pea (*Pisum sativum*), black gram (*Phaseolus mungo*) and Egyptian bean (*Dolichos lablab*) showed that among the *Rhizobium* strains from the same legume some strains are salt tolerant and possessed high efficiency of nitrogen fixation.

8 strains of *Rhizobium* from French bean (*Phaseolus vulgaris*) were also isolated from the root nodules of plants grown in Delhi, Hyderabad, Ranchi and Simla.

2. Bacterization Experiments.—Pot culture experiments conducted at Ranchi and Palampur showed statistically significant increase in the yield of soybean (*Soja max*) at Ranchi and of guar (*Cyamopsis tetragonoloba*) and berseem (*Trifolium alexandrinum*) crops at Palampur, due to seed inoculation with phosphobacterin. Significant increases in crop yields in majority of the field trials conducted with different crops under different climatic conditions were observed with phosphobacterin inoculation. Increased uptake of P_2O_5 in paddy (*Oryza sativum*) and wheat (*Triticum vulgare*) crops at Karnal was observed due to phosphobacterin inoculation in the plots where a basal dressing of F.Y.M. was given.

B. ALGAE

3. Availability of extra cellular products of the *Nostoc* strain to other organisms.—Studies were undertaken to find out whether the extracellular substances liberated by the *Nostoc* strain could be utilized by the alga itself as well as by other organisms. *Nostoc* strain and *Chlorella vulgaris* were used. It was found that both the *Nostoc* strain and *Chlorella vulgaris* were able to utilize the extracellular substances given off by the former. Besides, there was an indication that some thermolabile growth promoting substance might be excreted by the *Nostoc* strain. The active growth promoting principle in the filtrate was found to be unaffected by ultraviolet irradiation. The aged *Chlorella vulgaris* cultures seemed to form some thermolabile inhibiting substance.

PROGRAMME OF WORK FOR THE YEAR 1962

A. Soil Microbiology :

1. *Rhizobium* spp. of Indian cultivated and wild legumes.
2. Nitrogen transformation in Indian soils.
3. *Beijerinckia* in Indian soils.
4. Rhizosphere effects on micro-organisms.
5. Effect of vitamins and micro-nutrients on microbiological activities.
6. Bacterization of soils. (In collaboration with Division of Agronomy and State Departments of Agriculture).
- (a) *Rhizobium* inoculation
- (b) Phosphobacterin
- (c) Azotobacterin
- (d) Algae
7. Non symbiotic nitrogen fixation.
8. Ecology of soil microflora.

B. Algae Section :

1. Exploratory studies of algae of Indian soils.
2. Physiology of Algae.
3. Role of blue green algae on nitrogen economy of Indian soils.
4. Inter-relationships of algae and bacteria.

ALL INDIA SOIL AND LAND USE SURVEY

(Dr. S. V. Govinda Rajan)

The details of the research work carried out in the different soil correlation centres are given below :

BLACK SOIL REGION, NAGPUR.

Soil and land use survey was continued in the Mahanadi catchment in Sambalpur (Bhedan watershed) and Sundergarh (Ib watershed) districts of Orissa State and in Raigarh (Mand watershed) and Raipur districts of Madhya Pradesh. Soil survey was also in progress in Guntur district in Andhra Pradesh and Yeotmal district in Maharashtra State. The total area surveyed during the year was 9,17,798 acres. Soil and Land capability maps were prepared for all the areas.

The areas covered in the catchments and non-catchments are given in the following table.

State	District	Detailed; (acres)	Reconnai- ssance; (acres)	Total (acres)
1	2	3	4	5
<i>Mahanadi Catchment</i>				
Orissa	Sundargarh (Ib watershed)	1,57,212	98,223	2,55,435
	Sambalpur (Bhedan watershed)	32,732	..	32,73

1	2	3	4	5
Madhya Pradesh .	Raigarh (Mand watershed) . . .	57,338	12,394	69,732
	Raipur Main (Mahanadi) . . .	1,60,235	114	1,60,349
	TOTAL .	4,07,517	1,10,731	5,18,248
<i>Other Areas</i>				
Andhra Pradesh .	Guntur (Tobacco growing areas) .	38,872	..	38,872
Maharashtra .	Yeotmal taluk	..	2,10,678	2,10,678
	Wani Taluk	..	1,50,000	1,50,000
	TOTAL .	38,872	3,60,678	3,99,550
	GRAND TOTAL .	4,46,389	4,71,409	9,17,798

(1) **Bhedan watershed, Sambalpur district, Orissa under the Mahanadi catchment.**—This area is in a comparatively level terrain with paddy as the main crop. The paddy fields are well protected from soil erosion by bunds, but the cultivated uplands and forests are moderately to severely eroded. Soil Survey of 32,732 acres of the watershed on the right bank of the river Bhedan was completed and soil maps and land capability maps were prepared. The soils are found to be derived mainly from mica schists and feldspathic quartzite and have been classified into seven series based on horizontal variations, parent material, and presence or absence of lime.

(2) **Ib watershed in Hemgir P. S. Sundergarh district, Orissa under Mahanadi catchment.**—The entire area has a hilly and undulating topography. More than 50% of the land is occupied by mixed forest of *sal* and bamboo. The geology is complex, the main rock formations being granite, gneiss and mica schist in the north east part, shale mixed with mica along with haematite mainly in the Basundhara river basin and ferruginous sand stone in the south west part bordering on Raigarh District.

The total area surveyed and mapped in this region is 2,55,435 acres, out of which 1,57,212 acres were covered by detailed survey and the rest by reconnaissance. Seven soil series have been described in the area.

(3) **Mand watershed in Raigarh district, M.P. under Mahanadi catchment.**—The soils of the Mand watershed around Dharamajaygarh belongs to the broad group of red and yellow soils and have been derived from the rocks *in situ* or from their products of decomposition washed down to lower levels. Sand stone is the main rock formation of this area. The total area surveyed in the watershed is 69,732 acres. Two soil series have been established.

Chhal Series.—Surface layer is pale yellow to yellowish brown in colour, varying widely in texture from sandy loam to loam, with or without ferruginous concretions. No lime is present. Drainage is moderately rapid to rapid. This is followed by pale olive to dark red sub soil, loam and silty loam to clay loam in texture. Subsequent layers are silty loam and clay loam to clay, often mixed with coarse sand gravels or semi developed sand stone. Ferruginous concretions are present in abundance, but may sometimes be absent all together. Soils are acidic throughout the profile. This series is usually found in uplands.

Baisi Series.—This series is generally located on level to low land areas. The surface layer is olive grey to dark brown in colour varying widely in texture from silt, silty loam to silty clay, iron concretions are sometimes present but no lime. The subsoil is light olive brown to dark silty loam to silty clay, with or without iron concretions. The reaction in the entire profile is slightly acidic to neutral.

(4) **Main Mahanadi Catchment in Raipur district (Package Programme district), Madhya Pradesh.**—Soil survey was continued in Arang and Pallari Blocks of Raipur district and a total area of 1,60,349 acres was covered during the year and soil mapped. The soil belongs to the same three series which have been described earlier, and have been derived from shales, limestone and sandstone rock formations. Soil erosion is very severe on uplands which are classified under Lakholi series. Paddy lands under Arang and Chandkhuri soil series are, however, bunded and protected from soil erosion. Waste lands under Arang series have often gilgai microrelief.

(5) **Tobacco growing areas of Guntur district, Andhra Pradesh.**—Soil survey of tobacco growing areas in Guntur district was continued during the year and 38,872 acres were covered. The entire area is in a flat terrain with slope rarely exceeding 1.5%. Isolated granite domes are sometime present with occasional hillocks rising upto 400 to 500 ft. Only at the foot of these hills does the slope approach about 3%. Soil erosion is negligible in consequence of the flat topography. Drainage, however, is often impeded, in certain broad basic shaped depressions, where saline and alkali conditions are found to prevail.

The soils belong to the black soil group and two soil series have been encountered. The parent material is basic granite containing soda lime feldspar.

(i) *Tadikonda series.*—These soils occur on level to gently undulating lands and are texturally clayey throughout the profile with no marked horizontal differentiation. They are invariably deep, 6 ft. or more in depth with very dark grey to dark grey brown colour throughout. The structure is angular blocky upto about 20 inches, below which it is diagonally platy and this gradually transforms into small angular blocky. Lime is present throughout the profile. The soil reaction is moderately to strongly alkaline (pH 8 to 9) all along the profile depth.

A saline phase of this series is commonly met with in low lying areas and near stream banks.

(ii) *Endrayi series.*—These soils are situated at the gently sloping foot hills extending upto a few hundred feet around the hills dotting the area, which gradually merge into Tadikonda series. They are dark reddish brown to reddish brown in colour. The surface texture is coarse to medium being generally sandy and becomes clay to sandy clay in subsurface layers. The solum is moderately deep to very deep. The structure is prismatic. Lime is usually present in the lower horizons, either in a fine state or as small concretions. Iron concretions are also sometimes present along with lime. The soil reaction is neutral to mildly alkaline, the pH slightly increasing with depth.

Soil maps have been showing the boundaries of the different soil series and on these the distribution of soluble salts in varying concentrations has been demarcated by appropriate colours, the grouping being in terms of electrical conductivity, as (a) 0 to 0.3; (b) 0.3 to 1.0; (c) 1.0 to 5.0 and (d) 5.0 and above milli mhos per cm. Soluble chloride content of the soil has also been demarcated by appropriate differentiations, the ranges indicated being (a) 0.0-0.5%, (b) 0.05 to 0.02% and (c) 0.2% and above percentage of Chloride.

(6) **Soil Survey of Yeotmal district, Maharashtra State.**—A reconnaissance soil survey of a part of Yeotmal district was continued and about 1.5 lakh acres of Wani taluk was completed. Besides the three soil associations found earlier in Yeotmal taluk,

namely (i) deep dark clayey soils of Wardha valley, (ii) deep dark clay soils of Adav valley and (iii) reddish brown and dark grey soils of hilly areas, a fourth association which is deep clay soil in the low lands with reddish to reddish brown in colour was encountered. A typical profile of this association is described below:—

Village : Nimbala in Wani Taluka, Yeotmal district.

- 0-9 inches : Reddish brown (2.5YR4/4) Clay, subangular blocky, dry and semi hard with very few small lime concretions, moderately drained with moderately slow permeability.
- 9-22 inches : Reddish brown (2.5YR 4/4) clay, weak platy structure, moist and firm, few lime concretions moderately slow permeability.
- 22-36 inches : Reddish brown (2.5YR 4/4) clay, massive moist and firm, lime concretions increasing with depth, slowly permeable.
- 36 inches : Soil mixed with lime.

RED AND LATERITE SOIL REGION I, CALCUTTA

Soil survey was continued in the Catchments of Machkund and Hirakund and in other areas in the States of Orissa, West Bengal and Tripura. The total area surveyed during the period was 7,04,637 acres of which 81,307 acres were covered by detailed survey and 3,48,900 acres by detailed reconnaissance survey and 2,74,430 acres by reconnaissance survey. The particulars of the areas surveyed are given in the following table.

State	District or other particulars	Nature of survey			Total
		Detailed (acres)	Detailed Reconnais- sance (acres)	Reconnais- sance (acres)	
<i>Machkund Catchment</i>					
Andhra Pradesh	.	..	3,48,900	..	3,48,900
Orissa	. . . Koraput . . .	4,713	..	..	4,713
<i>Mahanadi Catchment</i>					
Orissa	. . . Sambalpur . . .	46,093	..	..	46,093
TOTAL		50,806	3,48,900	..	3,99,706
<i>Other Areas</i>					
Orissa	. . . Dandakaranya Project .	..	..	40,000	40,000
Orissa	. . . Puri . . .	12,699	..	..	12,699
Tripura		15,226	..	2,29,310	2,44,536
West Bengal	. . . Midnapore . . .	1,936	..	..	1,936
Nepal		640	..	5,120	5,760
TOTAL		30,501	..	2,47,430	3,04,931
GRAND TOTAL		81,307	3,48,900	2,47,430	7,04,637

1. Machkund Catchment, Andhra Pradesh

The catchment of Machkund river in this State consists of 22 sub-catchments totaling an area of about 610 square miles. During the year under report, survey of 21 sub-catchments in full and a part of the other sub-catchment were completed. A total area of 3,48,900 acres was covered by detailed reconnaissance survey.

The survey of India top-sheets of scale 1"=1 mile were enlarged to 8"=1 mile scale by Pantograph and the enlarged maps were used as base maps, since cadastral maps were not available for the area. The cultivated and cultivable areas were detail-surveyed while the inaccessible and steep hill slopes and forest areas were covered by reconnaissance survey.

The area is mostly hilly and is underlain at most places by khondalites and charnockites. The annual rainfall in this area is between 70 to 85", most of which is received in the south west monsoon.

The hills and hillsides which are subject to severe erosion hazard aggravated at many places by 'Podu' or shifting cultivation are very shallow in many places and are moderately deep in others. These are lateritic at places and non-lateritic at others. The 'Kallupada series' and 'Pippoluputtu series' which were established and reported earlier as also new series, viz. the 'Pattaputtu series' generally occur in these areas. In some sub-catchments soil associations have also been mapped.

The soils of the sloping uplands have been mapped under the previously established 'Hollangapadu series' and also a new series, namely the 'Araku series'. The latter belongs to the non-lateritic red soil group.

The low lands have soils similar to those of the previously established 'Devlupada series' and 'Kona series'.

Machkund Catchment, Koraput District, Orissa

An area of 4,713 acres was covered by detailed survey on 16"=1 mile scale village maps. The soils mapped correspond to one or other of the previously established series for the Machkund Catchment of this state.

2. Hirakud Catchment, Sambalpur District, Orissa

The Calcutta Centre took up the detailed survey of about 2506 square miles of this catchment by coordinating its programme with that of the Nagpur Centre with a view to rapidly completing the entire catchment. Of this area, about 2,010 square miles lie in Sambalpur district of Orissa state and the balance in Madhya Pradesh.

A total area of 46,093 acres has been surveyed in detail using the 16"=1 mile scale village maps. The survey area is characterised by an undulating to rolling physiography. Soils of the hillsides and of forested highlands are found to fall under 'Jharmunda series' (underlain by a conglomerated layer on weathering granite and mica schists) the 'Lapanga series' (underlain by laterite mass) or the 'Bhagipalli series' (underlain by quartz gravel horizon).

The undulating uplands, terraced for cultivation, have soils of 'Laomal series' (similar to 'Ekma cultivated' of the Nagpur Centre) or 'Bansimal series' (similar to 'Ekma noncultivated' of Nagpur Centre).

The lowlands have soils similar to 'Pamra' and 'Runga' series of the Nagpur centre.

A soil with a calcareous substratum very similar to 'Subdega series' of Nagpur Centre is also met with.

(3) Other areas

1. *Dandakaranya Project area, Orissa.*—A reconnaissance soil survey of the highlands in the rehabilitation areas in Umerkote was continued and an area of 40,000 acres was covered. A soil association maps was prepared. Further, a survey was commenced in

Malkangiri area, in Koraput district under Dandakaranya Project with the object of demarcating reserved forest lands that are suitable for clearance for the purpose of allotment to displaced persons.

2. *Mahanadi Delta Irrigation Project, Pipili P.S. Puri district, Orissa*—An area of 12,199 acres was surveyed. The soils were found to fall under one or other of the four series for the tract, described during the previous year.

3. *Tripura State*.—The reconnaissance soil survey of Belonia block development Centre was completed and 2,29,310 acres were surveyed.

Detailed soil survey of 15,226 acres was conducted in 9 mouzas for agricultural development and 4 mouzas where soil conservation demonstration farms are located.

4. *Kangsabathi Rehabilitation Project area, Midnapore district, West Bengal*.—Detailed soil survey of 1936 acres in Kangsabathi area for locating land suitable for allotment to displaced persons was continued and completed in the year 1961.

The soils were mapped under one or the other of the previously established series for the tract.

5. *Nepal*.—Detailed soil survey of Durbasa Khola and Bojour khola under the soil conservation centre in Chatra, extending over an area of 640 acres was completed.

A reconnaissance soil survey in Kosi Catchment area was also done over an area of 5,120 acres spread over 7 villages.

RED AND LATERITE SOIL REGION II, BANGALORE

During the period under report, reconnaissance and detailed soil survey in respect of areas in the four southern states, namely Andhra Pradesh, Kerala, Madras and Mysore were continued. Total area surveyed was 9,58,800 acres of which 96,880 acres were covered by detailed survey and 8,61,920 acres by reconnaissance survey. Laboratory studies of the various soils were also carried out. A detailed account of the survey areas is given below:—

State	District	Nature of Survey		Total (acres)
		Detailed (acres)	Recon- naissance (acres)	
Andhra Pradesh . . .	Chittoor	13,700	4,71,000	4,84,700
Kerala	Trivandrum	..	1,49,120	1,49,120
Madras	Coimbatore	..	76,800	76,800
Mysore	South Kanara	83,180	1,65,000	2,48,180
TOTAL		96,880	8,61,920	9,58,800

1. **Chittoor District, Andhra Pradesh**.—Reconnaissance soil survey of the Chittoor taluk involving an area of about 4,71,000 acres and detailed soil survey of eleven villages having an area of about 13,700 acres were completed. While reconnaissance soil survey was conducted with a view to prepare the soil map of the area and to locate problem areas requiring soil conservation measures against erosion and reclamation of salinity or alkali, the detailed soil survey was done at the request of the Panchayat Samiti of Chittoor taluk, in order to assess the extent of saline areas the extent of areas needing soil conservation and also to recommend better cropping patterns.

As a result of reconnaissance survey, it has been possible to classify the soils of the area into five series described earlier, namely the Yallamanda series, Vayalpad series, Mancheru series, Matianapalli series and Chittoor series.

The detailed soil survey of certain villages in the Panchayat Samiti area revealed that the soils of this area fall into the five soil series already described under the reconnaissance soil survey of Chittoor taluk. The soil maps have been interpreted and land use capability maps of the areas prepared.

2. Neyyattinkara taluk, Trivandrum district, Kerala.—The reconnaissance soil survey of Neyyattinkara taluk of Trivandrum district and detailed soil survey of a portion of the Neyyar catchment in the same taluk were taken up with the object of preparing a soil map of the taluk and to locate areas where soil conservation work has to be executed. This is the southernmost taluk of Kerala State and has an area of about 1,49,120 acres. Excepting for a narrow strip in the sea coast, the area is undulating. Towards the eastern portions, the terrain is hilly or mountainous, the highest point being at the top of the Agastye peak (6,340 feet above m.s.l). The climate is humid tropical with 60 to 100 inches of rainfall per annum. The area is drained by the Neyyar and the Karamana rivers and their tributaries. Luxuriant vegetation is observed throughout. The forest areas are densely covered with the timber trees, shrubby undergrowth and intertwining creepers typical of the humid tropical forests. Paddy, tapioca and coconut are the main crops of the area, with area and plantains occupying a minor position.

Depending upon the morphological characteristics, the soils of the area have been tentatively classified into nine series, *viz.*, Vizhinjam, Chenkal, Vilappil, Neyyattinkara, Mullur, Mukkunni, Karichal, Karamana and Puvar series. Of these, the first four belong to the soils generally described as laterite and lateritic soils, the next three belong to what are known as the red soils, the eighth is a river alluvium and the last a coastal alluvium.

The major distinguishing features of the different series are as follows :—

Series name	Distinguishing features
<i>(a) Laterite and lateritic soils</i>	
1. Vizhinjam series . . .	Deep laterite profile including a quarryable laterite horizon.
2. Chenkal series . . .	Presence of ferruginous and quartz gravel up to about 3 feet followed by shallow laterite horizon.
3. Vilappil series . . .	Soils derived from gneisses, abundance of bigger sized gravel of weathered parent material, original rock structure observed in laterised horizons.
4. Neyyattinkara series . . .	Red sandy loam soils underlain by gravelly laterite in the sub-surface layers.
<i>(b) Red Soils</i>	
1. Mullur series. . . .	Red loams of uniform texture and of considerable depth.
2. Mukkunni series . . .	Red sandy loam of moderate to shallow depth resting on weathered gneissic rocks.
3. Karichal series . . .	Deep red loams with the presence of ferruginous irregular stone line in the B ₂ horizon.
<i>(c) Alluvial soils</i>	
1. Karamana series . . .	River alluvium.
2. Puvar series	Coastal alluvium.

3. Coimbatore taluk, Madras.—An area of 76,800 acres was covered by reconnaissance survey in the taluk. The soils of the area surveyed had been tentatively classified into three series, one representing a red soil, another a black soil and the third an alluvial soil.

4. South Kanara District, Mysore.—An area of about 1,65,000 acres was covered by reconnaissance survey in this taluk. The soils of the area have been classified into five series namely, Puttur series, Vittal series, Nekkiladi series, Jalsoor series and Subrahmanya series.

A detailed soil survey of 29 villages in this taluk involving an area of about 83,200 acres has also been done with a view to demarcating the areas which are at present barren and subject to varying degrees of erosion and which can be afforested. The soils are found to belong to the first three series described under the reconnaissance soil survey *viz.* the Puttur, the Vittal and the Nekkiladi series. The types and phases of these series have been marked out in the soil map prepared. The land use capability map has been prepared taking into consideration the soil features and the topographic features.

The Central Arecanut Research Station Farm, Vittal, having an area of 180 acres was surveyed in a very detailed manner at their request. The scale of the base map was 150 feet=1 inch. A detailed soil map indicating the different series, types and phases has been prepared. It is noteworthy that in such a small area all the three soil series namely Puttur, Vittal and Nekkiladi series are observed showing that the area selected is representative of the major soils occurring in the locality.

ALLUVIAL SOIL REGION, DELHI

During the year under report soil survey and soil mapping were continued in the catchment areas of the Sutlej and Chambal and in the non-catchment areas of the Package Programme District of Ludhiana, in Punjab and the Chirgaon N.E.S. Block-Soil Conservation Project in Jhansi, Uttar Pradesh. The total area surveyed during the period was 1,78,476 acres.

The areas covered in the catchments and other locations are given in the following table.

State	District	Detailed (acres)	Recon- naissance (acres)	Total (acres)
<i>Sutlej Catchment</i>				
Himachal Pradesh	Bilaspur (Sirkhad)	16,781	..	16,781
	Mahasu (Alikhad)	12,638	..	12,638
	Mahasu (Gambharkhad)	12,281	..	12,281
Punjab	Kangra (Lunkarkhad)	8,554	..	8,554
<i>Chambal Catchment</i>				
Madhya Pradesh	Indore	85,641	..	85,641
	TOTAL	1,35,895	..	1,35,895
<i>Other Areas</i>				
Punjab	Ludhiana (Package District.)	17,422	..	17,422
	Jhansi (Chirgaon N. E. S. Block)	25,159	..	25,159
	TOTAL	42,581	..	42,581
	GRAND TOTAL	1,78,476	..	1,78,476

1. Sutlej (Bhakra-Nangal) Catchment

(i) Lunkar Khad ; Kangra District, Punjab—

Soil survey was completed in the Patwars of Bahi-Khargalta, Badhan, Dyugli and Mandli covering 8,554 acres. The series established are briefly described here.

Behal Series.—Pale brown to yellowish, non-calcareous colluvial light textured soils, mildly acidic to mildly alkaline occurring on gentle to strongly sloping land ; well drained, subject to water-table fluctuations ranging from 5 to 40 ft. and resting on non-calcareous sand-stone.

Balkhun series.—Pale brown to brown non-calcareous, colluvial, light textured soil, mildly acid to neutral, occurring on gentle to strongly sloping land, well drained, water table fluctuations range from 8 to 40 ft ; and resting on non-calcareous pink shales.

Bahi series.—Pale brown to yellowish brown, non-calcareous, light to medium textured soil ; mildly acid to neutral ; gently to moderately sloping land ; well drained ; water table fluctuates from 5 to 30 ft ; grading to mixed parent material of sand-stone and shale.

Rachho series.—Pale brown to drab brown, non-calcareous medium texture, mildly acid ; gentle to strongly sloping ; moderate to slow permeability ; mixed parent material of shale and sandstone with almost vertical strike.

Dhatol Series.—Brownish yellow to yellowish brown, calcareous, medium texture soil, neutral to mildly alkaline ; gently to strongly sloping ; well drained and permeable old alluvium.

Arlukhas Series.—Pale brown to brown, calcareous, light texture, mildly alkaline ; moderately to steep by sloping ; well drained ; moderate to rapid permeability developed from grey calcareous sandstone.

Hathloon series.—Pale brown to yellowish brown, non-calcareous ; colluvial light textured soil, neutral ; gently to strongly sloping ; well drained ; water table 6 to 40 ft. calcareous grey sandstone parent material.

Donkhar series.—Light grey to grey, non-calcareous, light textured soil with gravel, mildly acid, gently to strongly sloping well drained ; rapidly permeable ; mixed colluvium overlying old alluvium.

Karor Brahman series.—Very pale brown to yellowish brown, non-calcareous soil ; light textured and neutral in reaction. Gentle to moderate slope ; well drained, moderate to rapid permeability ; water table fluctuation ranging from 10 to 30 ft ; grey non-calcareous sandstone.

(ii) Sirkhad and Sutlej, Bilaspur District, Himachal Pradesh

Soil survey was continued in 76 villages comprising an area of 16,781 acres falling in the Patwars of Bhupral, Barota, Hatwar, Mori Katla and Talyana. A new series Barog (complex) was established, besides Balkhun and Karor Brahman series mapped in Lunkar Khad. The other series mapped in the area are Swarghat, Dagra, Nuswal, Rona and Dhar Khansi.

(iii) Alikhad, Mahasu District, Himachal Pradesh

The soil survey of the catchment was continued in the Patwars of Sirkanj and Panjgi comprising an area of 12,638 acres. The series found in this area were Kandror, Kothi Bampata, Bandla, Neras, Namol, Manling, Pilliani, Ktola and Dawan.

(iv) *Gambharkhad, Mahasu District, Himachal Pradesh*

Detailed soil survey of an area of 4,266 acres in Rao Khad was completed. The soils are covered by the Saproon series. The survey of 52 villages in Kuthar and Dabar nadi catchments covered an area of 8,015 acres in Chhausa and Sabathu patwars.

2. Chambal Catchment, Indore District, Madhya Pradesh

Soil survey work was continued in the catchments of Khan, Gambhir and Awan Rivers. In addition, soil survey was started in the Upper Shipra River Catchment.

In the Khan River Catchment 26 villages comprising an area of 25,526 acres were surveyed. The area surveyed is between Saver and Indore on both sides of the river Khan. The mean annual rainfall ranges between 35 and 50 inches. The topography in the cultivated fields varies from level to gently sloping and the gradients increase when the streams are approached. On the hills, soils are shallow and mixed with rock fragments. The parent materials predominantly constitute the trap rocks of Vindhya. The soils are classified into 4 series.

Baloda series.—It comprises of dark grey to grey deep clay soil medium moderate subangular blocky, calcareous and moderately alkaline. A grading to grey to dark grey clay with many iron and lime concretions ; medium to coarse moderate subangular blocky and moderately alkaline B Horizon. These soils occur on nearly level to gently sloping land. The soils are moderately well drained from the surface and subsoil permeability is slow.

Kamliakheri series.—It comprises of grey to dark grey shallow clay soils with medium moderate subangular blocky structure, neutral slightly calcareous A horizon, grading to grey to dark grey clay with small lime concretions, fine moderate subangular blocky, mildly alkaline slightly calcareous B horizon grading to the C. Such soils also occur on nearly level to gently sloping land with gradients of 1 to 3%. Soils are moderately well drained from the surface and permeability is slow.

Brahmankheri Series.—It comprises of light gray deep clay loam to silty clay loam mixed with small lime concretions. Posses fine subangular blocky structure with a moderately alkaline A horizon grading to pale brown silty clay, subangular blocky, calcareous and moderately alkaline B. Such soils occur on level to gently sloping land. These soils are moderately well drained from the surface with moderately good internal drainage.

Panchdaria Series.—It comprises of shallow dark brown clay loam to clay soil. Posses weak subangular blocky structure, are slightly clacareous with a mildly alkaline A horizon grading to dark brown silty clay to clay, moderate blocky hard and sticky, calcareous moderately alkaline B merging into C. Such soils occur on strongly sloping to steep hills.

In Gambhir River Catchment detailed soil survey of about 25,000 acres covering 24 villages was compeleted. This is an adjoining area of Khan river. The physiography, relief and drainage conditions are almost similar to those described in Khan, but erosion is more severe and gullies are common. All the 4 Soil Series recognised in Khan catchment have been mapped here.

The Awan nadi is a tributory of Retama River which joins Chambal 8 miles down stream. Detailed Soil Survey of 35,115 acres covering about 23 villages in Malhargarh Tehasil of District Mandasaur was completed. The series established here are described briefly :

Apukheri series.—Comprises of dark grey, gravelly non-calcareous heavy textured, surface horizon grading to dark grey slightly clacareous subsoil and weathered pale yellow rock material.

Harsor series.—Comprise of black, slightly calcareous, heavy textured Ap horizon grading to black, slightly calcareous, heavy textured B horizon and a horizon of calcium carbonate accumulation.

Lunahera Series.—Comprises of shallow dark greyish-brown, noncalcareous, medium textured Ap horizon, grading to dark grey brown weathered rock.

Gurbhali series.—Comprises of deep dark-brown, calcareous, heavy textured soils, grading to dark-brown calcareous, heavy textured B. These occur on 1 to 2 % slopes; and are moderately well drained.

3. Other Areas

Chirgaon N.E.S. Block—Soil

Conservation Project, District Jhansi, Uttar Pradesh.—In this N.E.S. Block, a total area of 25,159 acres have been surveyed. Both field and laboratory characterization have been made, as a result of which 4 soil series and a miscellaneous land type have been established.

Series 1 comprises of generally light textured and occasionally medium textured pale brown to brown non-calcareous neutral A grading to generally medium textured and occasionally heavy textured pale brown to brown, non-calcareous, mildly alkaline B grading to Ca below 40 to 53 inches. Such soils occur on nearly level to moderately sloping land with gradients of 0 to 0.5 per cent. They are excessively drained to well drained from the surface and moderately well drained internally.

Series 2 comprises of generally medium textured and occasionally heavy textured light brownish gray to grayish brown, non-calcareous, mildly alkaline A grading to heavy textured grayish brown to dark grayish brown, non-calcareous, mildly alkaline B grading to Cca below 40 to 52 inches. Such series occur on nearly level to gently sloping land with gradients of 1 to 3 per cent. They are well drained to moderately well drained from the surface and moderate, internally.

Series 3 comprises of heavy textured grayish brown to dark grayish brown, non-calcareous, neutral A grading to heavy textured grayish brown to dark grayish brown, slightly calcareous mildly alkaline B grading to Ca below 44 to 69 inches.

Series 4 comprises of light textured yellowish brown to dark brown, slightly calcareous, mildly alkaline A grading to medium textured brown to dark brown highly calcareous moderately alkaline B grading Ca below 32 to 60 inches.

Besides the 4 series, a miscellaneous Land Type *viz.* badly eroded and gullied land has also been mapped.

Ludhiana Package Programme District Punjab

Detailed soil survey of about 11 selected villages covering an area of 11,000 acre was completed. Five soil series were recognised and described. Series 1 comprises of 4 to 24" thick sand to loamy sand, loose, structureless A grading to a weakly blocky very friable loamy sand B. These soils are excessively drained.

Series 2 comprises of brown to yellowish brown loamy sand to sandy loam, very weakly granular and very friable A grading to brown to dark brown sandy loam, medium moderately blocky, friable, slightly sticky B, sometimes grading to Cca.

Series 3 comprises of brown to yellowish brown loamy fine sand to fine sandy loam, weak to moderately granular, friable A grading to dark brown loam, moderately blocky friable B with a few dark iron and manganese concretions, sometimes grading to Cca.

Series 4 comprises of brown to dark yellowish brown sandy loam to loam, medium weakly granular A grading to dark yellowish brown silt loam, moderate to strongly blocky friable to firm B grading to Cca below 24 to 72 inches.

Series 5 comprises of brown to dark yellowish brown fine sandy loam to silt loam weakly granular and weakly to moderately blocky slightly friable A grading to dark brown silty clay loam, medium to coarse strongly blocky, firm, very sticky B grading to Cca 46 to 68 inches.

Reclamation of saline-alkali soils in Khanjawala Block of Delhi State

In Khanjawala Block there are quite a number of sizeable saline-alkali areas in the cultivators fields besides few large uncultivated tracts which require immediate attention. The surface drainage of the area is very defective and there is not sufficient natural drainage system for the efficient exit of rain water. A set of soil samples taken in the cultivator's fields showed that the surface soils had pH varying from 7.2 to 10.1, the total salt content in terms of electrical conductivity of the saturation extract varying from 2.6 to 80.0 mmhos/cm. Total gypsum requirement of the soils varied from 4 to 11 tons per acre foot. In general the electrical conductivity changes from 75.0 milli mhos/cm. on the surface to 4.0 milli mhos/cm. below 3 feet depth.

Areas marked for reclamation were enclosed with medium sized bunds to arrest rain water. Gypsum was applied at later stages at the rate of only 0.5 to 2 tons per acre with a view mainly to keep a favourable balance of salts in the surface soils so that physical conditions would not deteriorate.

Subsequent soil test values revealed appreciable drop in electrical conductivity but little change in the pH values.

Cartographic Laboratory, I.A.R.I., New Delhi

(i) An attempt has been made to delineate approximate boundaries of Basic Land Resource areas of India by super-imposition of vegetation data on climatic map.

(ii) Colour values according to standard Munsell system have been determined for delineation of the vegetation zones on Cape Comrin sheet in the scale 1:1 million.

(iii) Dimensional stabilities of standard papers produced in the country for soil map printing has been completed.

(iv) Routine work on map compilation, fair mapping and photolithographic reproduction was continued.

I	2	3	4	5	6	7	8	9	10	11
3	Red and Laterite Soil Region I, Calcutta.	Machkund (Orissa A.P.) Mahanadi (Orissa)		14,747 2,88,000	13,853 ..					18,600
							Dandakaranya, (Orissa) Tripura State Pipli P. S., (Orissa) Badua Dam, Catchment (Bihar)	 27,000 48,000	22,500 1,20,000	2,88,000 22,500 1,20,000 27,000 48,000 48,000
								GRAND TOTAL		5,24,100
4	Red and Laterite Soil Region II, Bangalore.	Neyyar	..	..	20,000	..	Madras, (Coimbatore Distt.) Mysore Bantwal taluk Hassan Distt. Kerala Trivandrum taluk Andhra Pradesh Nellore.	20,000 50,000 20,000 20,000	1,00,000 2,00,000 1,10,000 1,00,000	1,20,000 2,70,000 1,30,000 1,20,000
								GRAND TOTAL		6,40,000

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11. Raychaudhuri, S. P. and (1961) Classification of rice soils of India Internatl.
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V. GAZETTED STAFF OF THE INSTITUTE

DIRECTORATE

1. Director	Dr. B. P. Pal, M.Sc., Ph.D. (Cantab.), FLS. F.B.S., F.N.I.
2. Joint Director	Dr. R. S. Vasudeva, D.Sc. (Lond.), Ph.D. (Lond.), D.I.C., F.N.I.
3. Dean	Dr. A. B. Joshi, M.Sc., Ph.D., Assoc. I.A.R.I. (From 10th November, 1961).
4. Registrar	Shri Vas Dev, B.A. (From 1st, December, 1960).
5. Deputy Registrar	Shri V. S. Bendre, B.A. (From 18th March, 1961).
6. Assistant Registrar	Shri S. L. Vachher, B.A. (Hons.), M.A.
7. Accounts Officer	Shri P. Thiagrajan, B.Sc. (from 12th September, 1961).
8. Documentalist	Shri N. N. Chatterjee, B.Sc., Diploma in Librarianship, Proficiency certificates in French, German & Russian.
9. Librarian	Shri S. P. Phadnis, B.Sc., M.A. (Lib. Sci.) (From 8th December, 1961).
10. Photographer	Shri H. K. Gorkha.
11. Stores Officer	Shri P. B. Lal, M.A. (from 15th May, 1961)
12. Superintendent, Accounts	Shri G. S. Lala, B.A.

DIVISION OF AGRONOMY

1. Head of the Division	Dr. O. P. Gautam, M.Sc. (Ag.), Ph.D. (Calif.)
2. Agronomist	Shri S. Sen, M.Sc.
3. Agronomist	Dr. R. D. Verma, B.Sc. (Hons.), (Edin.), M. S. (Iowa) Ph.D. (Lond.); (from 2nd December, 1959 upto 16th November, 1961).
4. Agronomist	Dr. K. S. Yawalkar, B.Sc. (Ag.), Ph.D., Assoc. I.A.R.I.
5. Assistant Agronomist	Shri R. T. Gandhi, B.Sc. (Ag.), Assoc. I.A.R.I.
6. Cattle Officer	Dr. Gian Singh, L.V.P. (Hons.), P. G. Mukteswar.
7. Assistant Professor of Agronomy	Dr. N. G. Dastane, B.Sc. (Ag.) (Hons.), M.Sc. (Ag.), Ph.D. (Qld.)
8. Assistant Prof. of Agronomy	Shri Rajendra Pal Singh, M.Sc. (Ag.), Assoc. I.A.R.I.
9. Farm Superintendent	Dr. A. S. Sandhu, B.Sc. (Ag.) (Kansas), Ph.D.

Statistics Section

1. Head of the Section Dr. P. N. Saxena, M.A., Ph.D.
2. Assistant Prof. of Statistics . . . Shri G. Sadasivan, M.Sc. (Statistics).
3. Assistant Statistician Shri A. G. Kavitkar, B.Sc., Assoc. I.A.R.I.

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AGRIL. EXTENSION DIVISION

1. Head of the Division Shri A. R. Khan, B.Sc. (Ag.), M.Sc. (Wiscon.),
Assoc. I.A.R.I. (from 25th October, 1960).

Division of Agril. Economics

1. Farm Management Extensionist Shri S. L. Chaudhuri, B.Sc. (Ag.), M.A. (Econ.), Assoc. I.A.R.I. (from 9th June, 1961).
2. Assistant Economic Statistician . Shri S. K. Goel, M.Sc. (from 26th August, 1961).

DIVISION OF BOTANY

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Dr. M. S. Swaminathan, B.Sc. (Ag.), Ph.D. (Cantab.) Assoc. I.A.R.I. (from 10th December, 1961).
2. Prof. of Botany Dr. R. D. Asana, M.Sc., Ph.D., D.I.C.
3. Geneticist Dr. N. L. Dhawan, M.Sc., Ph.D., Assoc. I.A.R.I.
4. Cytogeneticist Dr. M. S. Swaminathan, B.Sc. (Ag.), Ph.D. (Cantab.), Assoc. I.A.R.I. upto 30th November, 1961.
5. Asstt. Prof. of Botany Shri M. V. Rao, M.Sc.
6. Asstt. Prof. of Botany Shri M. W. Hardas, M.Sc., Assoc. I.A.R.I.
7. Asstt. Prof. of Botany Dr. S. V. S. Shastry, B.Sc. (Ag.), M.S. (Wis.), Ph.D. (Wis.) from 23rd December, 1958 upto 20th March, 1961.
8. Asstt. Plant Physiologist Shri T. J. Malkani, M.Sc.
9. Asstt. Cytogeneticist Shri A. T. Natarajan, M.Sc., Assoc. I.A.R.I.
10. Asstt. Agrostologist Shri B. D. Patil, B.Sc. (Ag.) (Hons.), (trained in Grass land Ecology U.S.A.)
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12. Asstt. Geneticist Shri R. K. Mehta, B.Sc., Assoc. I.A.R.I.
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12. Asstt. Organic. Chemist . . Dr. A. R. S. Kartha, M.Sc., Ph.D.
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15. Asstt. Agril. Chemist . . . Dr. V. Iswaran, M.Sc., Ph.D.
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9. Asstt. Ecologist . . . Dr. S. K. Bhatia, M.Sc., Ph. D. Assoc. I.A.R.I., (from 12-4-61).
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3. Systematic Mycologist . . . Shri R. L. Munjal, M.Sc., (from 10-1-61).
4. Asstt. Prof. of Plant Pathology . . Dr. D. N. Srivastava, M.Sc., (Wis.), Ph.D. (Wis.), Assoc. I.A.R.I.
5. Asstt. Prof. of Plant Pathology . . Shri T. K. Nariani, B.Sc. (Ag.) (Hons.), Assoc. I.A.R.I.
6. Asstt. Prof. of Plant Pathology . . Shri R. L. Munjal, M.Sc. (upto 10-10-61).
7. Asstt. Prof. of Plant Pathology . . Dr. M. M. Payak, M.Sc. (Ag.), Ph.D. (from 11-10-61).
8. Asstt. Prof. of Plant Pathology . . Shri M. S. Chatrath, M.Sc.
9. Asstt. Virus Pathologist . . . Shri H. S. Sahambi, M.Sc.
10. Herbarium Keeper . . . Shri J. N. Kapoor, M.Sc., Assoc. I.A.R.I.
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3. Asstt. Engineer . . . Shri R. P. Singh, B.Sc. (Agril. Engg.), M.Sc. (Agr.).
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Dr. S. K. Mukherjee, M.Sc., D.Sc. (from 21-4-61).

2. Prof. of Horticulture . . . Dr. G. S. Randhawa, M.Sc., Ph.D., M.S.A.
(Toronto) from 21-4-61.
3. Horticulturist . . . Dr. R. N. Singh, M.Sc., Ph.D.
4. Vegetable Breeder . . . Dr. B. Chowdhury, Ph.D. (Melb.) FRHS.
5. Fruit Preservation Officer . . . Shri N. L. Jain, M.Sc. (Tech.).
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8. Asstt. Horticulturist . . . Shri N. Nath, M.Sc., Assoc. I.A.R.I.
9. Superintendent of Gardens . . . Shri Ramesh Chandra, B.Sc. (Ag.).
10. Asstt. Vegetable Breeder . . . Shri P. M. Bhagchandani, B.Sc. (Ag.), Assoc.
I.A.R.I.
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12. Asstt. Geneticist . . . Shri P. K. Majumdar, B.Sc. (Ag.), Assoc.
I.A.R.I.

Agricultural Research Sub-station, Karnal

1. Asstt. Agronomist . . . Shri Mahendra Singh, M.Sc. (Ag. Bot.),
Assoc. I.A.R.I. from 25-1-60.

Botanical Sub-station, Pusa

1. Botanist . . . Shri M. D. Nandkeolyar, M.Sc. (from 23-5-60
to 20-3-61).
Dr. S. V. S. Shastry, B.Sc., Ph.D. (Wis.)
(from 21-3-61).
2. Superintendent . . . Shri M. D. Nandkeolyar, M.Sc. from 21-3-61.

Central Vegetable Breeding Sub-station, Katrain

1. Vegetable Specialist . . . Dr. Vishnu Swarup, M.Sc., Ph.D., Assoc.
I.A.R.I.
2. Floriculturist . . . Shri J. N. Sharma, B.Sc., Assoc. I.A.R.I.

Coordinated Scheme on Floriculture

1. Asstt. Horticulturist (Floriculture) . . . Shri R. S. Malik, M.Sc. (Agri. Hort.).

Coordinated Wheat Rust Control Scheme (Botanical Portion)

Delhi Centre :

1. Wheat Breeder . . . Dr. S. P. Kohli, M.Sc., Ph.D.
2. Asstt. Wheat Breeder . . . Shri K. B. L. Jain, B.Sc. (Ag.), Assoc.
I.A.R.I.
3. Asstt. Statistician . . . Shri Daljit Singh, B.Sc., Assoc. I.A.R.I.

Simla Centre :

Asstt. Wheat Breeder Dr. Jogindar Singh Bakshi, M.Sc., Ph.D.

Indore Centre :

Asstt. Wheat Breeder Shri V. S. Mathur, M.Sc., (Ag.) upto 12-10-61.
Shri Y. M. Upadhayaya, B.Sc., Assoc. I.A.R.I.

Wellington Centre :

Asstt. Wheat Breeder Dr. V. K. Srinivasan, M.Sc., Ph.D.

Pusa Centre :

Asstt. Wheat Breeder Shri Y. M. Upadhayaya, B.Sc., Assoc. I.A.R.I.
upto 30-9-61.
Shri V. S. Mathur, M.Sc. (Ag.).

Bhawali Centre :

Asstt. Wheat Breeder Shri R. K. Agarwal, M.Sc., Assoc. I.A.R.I.
(from 10-5-60).

Coordinated Maize Breeding Scheme

1. Senior Maize Breeder Dr. R. L. Paliwal, M.Sc., Ph.D. (from 22-3-61).
2. Maize Breeder Dr. K. L. Mehra, M.Sc., Ph.D.
3. Asstt. Maize Breeder Shri Joginder Singh, B.Sc., Assoc. I.A.R.I.

Coordinated Wheat Rust Control Scheme (Mycological Portion)*Delhi Centre :*

Mycologist Dr. R. Prasada, M.Sc., D.Sc. (Agr.).

Simla Centre :

1. Asstt. Mycologist Shri V. C. Lele, M.Sc. (Agri. Bot.).
2. Asstt. Mycologist Dr. Sheodhan Singh, M.Sc. (Ag.), Ph.D.
(Minn.).
3. Asstt. Mycologist Dr. M. M. Payak, M.Sc., (Ag.) Ph.D. (upto
10-11-1961),

Wellington Centre :

Asstt. Mycologist Shri L. M. Joshi, M.Sc.

Plant Introduction and Exploration Organisation*Delhi Centre (Botanical Portion) :*

1. Plant Introduction Officer Shri H. B. Singh, M.Sc., Assoc. I.A.R.I.
2. Asstt. Botanist Shri S. P. Mital, M.Sc., Assoc. I.A.R.I.

Simla Centre :

Asstt. Botanist Shri S. A. Dadlani, B.Sc., Assoc. I.A.R.I.

Delhi Centre (Mycological Portion) :

Asstt. Plant Pathologist . . . Dr. Gopal Swarup, M.Sc., M.S., Ph.D., Assoc. I.A.R.I.

Coord. Scheme of Simple Fertilizer Trials in Cultivator's Fields and Model Agron. Experiments

1. Agronomist . . . Dr. H. S. Mann, B.Sc., M.Sc., Ph.D. (Kansas).
2. Asstt. Agronomist . . . Shri M. L. Bhendia, M.Sc. (Ag.), Assoc. I.A.R.I. (from 14-6-61).

Project for Irrigation Investigation

1. Agronomist . . . Dr. Mukhtar Singh, M.Sc. (Ag.), Ph.D.
2. Asstt. Agronomist . . . Shri S. L. Chaudhury, B.Sc., M.A., Assoc. I.A.R.I. (from 4-6-60 upto 8-6-61).

Project for setting up P.G. Course in Agriculture Extension

1. Prof. of Agri. Extension . . . Shri S. L. Vishnoi, B.Ag. (Nag.), M.S. (USA) (upto 25-7-61).
2. Agril. Development Officer . . . Shri B. S. Joon, M.Sc. (Ag.), (from 5-11-60).

Scheme for the Improvement of Pasture Grasses

Asstt. Agronomist (Fodder) . . . Shri N. K. Chopra, B.Sc., Assoc. I.A.R.I.

Scheme for Investigation on Weed Control

1. Agronomist . . . Shri V. S. Mani, M.Sc.
2. Asstt. Agronomist . . . Shri R. B. L. Bhardwaj, B.Sc., Assoc. I.A.R.I.

Project for Plant Tissue and Spray Fertilizer Investigation Scheme

1. Agronomist . . . Dr. S. S. Bains, Assoc. I.A.R.I., Ph.D.
2. Asstt. Agronomist . . . Dr. J. Seth, B.Sc. (Ag.), M.Sc., Ph.D.

Scheme for Investigations on Phosphorus Fertilization of Cotton by Radio Tracer Technique

1. Asstt. Agronomist . . . Shri S. L. Pande, B.Sc. (Ag.), Assoc. I.A.R.I. (from 4-2-61).
2. Asstt. Agronomist . . . Dr. N.N. Goswami, B.Sc. (Ag.), Assoc. I.A.R.I., Ph.D. (from 18-9-61).

Scheme for the Survey of Additional Indigenous Agril. Implements at I.A.R.I.

Mech. Engineer . . . Shri T. H. Nirmal, B.Sc. (Ag. Eng.), M.S. (Illinois) (from 4-1-61).

Scheme for the Establishment for Embryoculture

Asstt. Cytogeneticist . . . Shri R. D. Iyer, M.Sc. (from 13-7-61).

Scheme of Establishment of Research-cum-testing Centre & Bullock Drawn Implements

Research Engineer Shri J. R. Badola, B.Sc. (Agri. Eng.).

Scheme for Use of Radio Active Isotopes in Cytogenetic Studies

1. Asstt. Cytogeneticist Shri D. Jagathesan, M.Sc. (Bot.).
2. Asstt. Physiologist Shri R. N. Mukherjee, M.Sc. (Bot.).

Scheme for Setting up Seed Testing

1. Seed Testing Officer Dr. S K. Kamra, M.Sc., Dr. Rel-met (Germany) (from 18-12-59 to 30-9-61).

Scheme for Improvement of Essential Oil Yielding Plants at I.A.R.I.

Delhi Centre :

Asstt. Botanist Shri B. S. Joshi, B.Sc. (Ag.), Assoc. I.A.R.I. (upto 23-10-61).

Katrain Centre :

Asstt. Botanist Shri S. C. Pokhriyal, M.Sc., Assoc. I.A.R.I. (upto 31-3-61).

Jamnagar Centre :

Asstt. Botanist Shri M. G. Joshi, B.Sc. (Ag.), Assoc. I.A.R.I. (upto 31-10-60).

Section for the Improvement of Essential Oil Yielding Plants

1. Chemist Shri T. C. K. Menon, M.Sc. (from 24-10-61).
2. Asstt. Botanist Shri B. S. Joshi, B.Sc., Assoc. I.A.R.I. (from 24-10-61).

Additional Staff for the Plant Breeding and Genetics Section of the Botany Division, I.A.R.I.

1. Geneticist Shri Ranjit Singh, M.Sc., Assoc. I.A.R.I. (from 23-3-61).
2. Geneticist Shri S. Ramanujam, B.Sc. (Hons.), Assoc. I.A.R.I.
3. Geneticist Shri W. T. Butany, B.Sc., Assoc. I.A.R.I.
4. Asstt. Geneticist Shri S. M. Vaidya, B.Sc., Assoc. I.A.R.I.
5. Asstt. Geneticist Shri S. S. Rohewal P. G., I.C.A.R.
6. Asstt. Geneticist. Shri S. C. Pokhriyal, M.Sc., Assoc. I.A.R.I. (from 1-4-61).

I.A.R.I.—Scheme for the Study of Genetics and Variability of Algae

Asstt. Botanist Shri G.S. Venkataraman, M.Sc. (upto 14-10-61).

Scheme for the Improvement of Water Melon and Musk Melon

Asstt. Botanist Shri Sada Nand M.Sc. (Ag.) (from 26-9-60 to 31-5-61).

Scheme on Cytogenetical and Physiological Studies in Relation to Floriculture

Asstt. Cytogeneticist Shri S. S. Rajan, M.Sc. (from 21-3-60 to 30-11-61).

Scheme for the Establishment of Fundamental Plant Genetical Research Laboratory at I.A.R.I.

Section of Cytology & Cyto-Chemistry :

1. Cytologist Dr. H. K. Jain, Ph.D., Assoc. I.A.R.I. (from 14-2-59).
2. Asstt. Cytologist Shri M. P. Singh M.Sc.

Section of Genetics & Immunology :

1. Genetics Dr. M. L. Magoon, B.Sc. (Bot.), B.Sc., (Hons.), M.Sc. (Hons.), M.Sc. (Wis.), Ph.D. (Wis.), (from 23-6-59).
2. Asstt. Geneticist Shri V. L. Chopra, B.Sc. (Hons.) (Ag.), Assoc. I.A.R.I.
3. Asstt. Botanist Shri M. G. Joshi, B.Sc. (Ag.), Assoc. I.A.R.I. (from 1-11-60).

Section of Physiological & Biochemical Genetics :

1. Geneticist Shri S. S. Rajan, M.Sc. (from 1-12-61).
2. Biochemist Dr. B. M. Lal, M.Sc., Ph.D. (from 25-2-60).
3. Asstt. Plant Physiologist Shri A. D. Saini, M.Sc. (from 2-12-60).

Section of Biometrical Genetics :

1. Geneticist Dr. B. R. Murthy, B.Sc., Ph.D., Assoc. I.A.R.I. (from 30-8-61).

Scheme for the Studies of Chappati Making and Baking Quality of Indian Wheat

Asstt. Plant Physiologist Dr. A. Austin, M.Sc. (Ag.), D.Sc. (Holland).

Coordinated Scheme for Citrus Die Back Disease

Asstt. Plant Physiologist Dr. M. N. Sarin, M.Sc., Ph.D.

Scheme for Radio Tracer Investigation for Assessment of Soil Fertility

1. Soil Scientist Dr. B. V. Subhiah, M.Sc., Ph.D.
2. Asstt. Soil Chemist Dr. S. C. Srivastava, M.Sc., Ph.D.

ALL INDIA SOIL AND LAND USE SURVEY SCHEME

Delhi Centre :

1. Chief Soil Survey Officer . . . Dr. S. P. Raychaudhuri, M.Sc. Ph.D. (Lond.), D.Sc. (Lond. Cal.), FRIC. (upto 13-8-61).
Dr. S. V. Govindaraja, B.Sc. (Hons.), Ph.D. (Lond.), DIC., ARIC. (from 14-8-61).
2. Soil Correlator . . . Dr. K. V. S. Satyanarayana, B.Sc. (Ag.), Ph.D., Assoc. I.A.R.I.
3. Soil Conservation Officer . . Dr. N. R. Datta Biswas, M.Sc., Ph.D.
4. Asstt. Soil Conservation Officer . Shri R. S. Murthy, M.Sc.
5. Soil Chemist . . . Shri R. K. Chibber, B.Sc., Assoc. I.A.R.I.
6. Asstt. Soil Survey Officer . . Shri S. P. Gupta, B.Sc., Assoc. I.A.R.I.

Nagpur Centre :

1. Soil Correlator . . . Dr. B. B. Roy, M.Sc., Ph.D. (from 8-1-57).
2. Asstt. Soil Conservation Officer . Shri Y. P. Bali, B.Sc. (Hons.), Assoc. I.A.R.I. (from 22-8-59).
3. Soil Chemist . . . Shri N. K. Barde, M.Sc. (Ag.).

Bangalore Centre :

1. Soil Correlator . . . Dr. S. V. Govindarajan, B.Sc. (Hons.), Ph.D. (Lond.), DIC., ARIC. (from 3-2-56 to 13-8-61).
2. Asstt. Soil Conservation Officer . Shri P. K. Thomas, B.Sc., Assoc. I.A.R.I.

Kharagpur Centre :

1. Soil Correlator . . . Shri S. Digar, M.Sc., Dip. Agri. (Calcutta).
2. Asstt. Soil Conservation Officer . Shri T. R. Srinivasan, B.Sc., Assoc. I.A.R.I.
3. Soil Chemist . . . Shri J. C. Bhattacharjee, M.Sc.

Scheme for Cartographical Laboratory for Soil Mapping

Cartographer . . . Shri L. M. Mathur, M.A.

Scheme for Expanded Soil Testing Service under Supplement to Operational Agreement No. 4*Delhi—I.A.R.I.:*

Special Officer . . . Dr. N. P. Datta, M.sc., D.Sc., ARIC.

Rajahmundry Centre :

Asstt. Soil Chemist . . . Shri P. V. Anantharaman, B.Sc. (Ag.), Assoc. I.A.R.I.

Junagarh Centre :

Asstt. Soil Chemist Shri Baljit Singh, B.Sc. (Ag.), Assoc. I.A.R.I.
(from 24-3-60).

Kanpur Centre :

Asstt. Soil Chemist Shri N. B. Paul, B.Sc., Assoc. I.A.R.I. (from
30-5-61).

Delhi Centre :

Asstt. Soil Chemist Shri M. S. Khera, M.Sc.

Balehonnur Centre :

Asstt. Soil Chemist Shri P. K. Mathew, M.Sc. (upto 15-6-61).

Agartala Centre :

Asstt. Soil Chemist Dr. A. N. Sen, M.Sc. (Hons.), Ph.D. (upto
23-6-61).

Jodhpur Centre :

Asstt. Soil Chemist Shri S. P. Seth, M.Sc. (Hons.) (upto 9-6-61).

Jubbulpur Centre :

Asstt. Soil Chemist Shri V. K. Misra, B.Sc., Assoc. I.A.R.I.

D.V.C. Centre (Hazaribagh) :

Asstt. Soil Chemist Shri R. K. Asthana (upto 14-6-61).

**Scheme for Examining the Behaviour of certain additional Chemical
Fertilizer under Storage Condition**

Fertilizer Technologist Shri M. A. Idnani, B.Sc., Assoc. I.A.R.I. (upto
14-9-59) Dr. A. Sen, M.Sc., Ph.D. (from 2-12-59).

Unit of Physics Scheme

1. Senior Physicist Dr. C. Dakshinamurti, M.Sc., D.Sc., Ph.D.
(Lond.), F. Inst. P. (Lond.).
2. Applied Physicist Dr. A. R. Deb, M.Sc., D.Phil.
3. Asstt. Physicist Dr. G. S. R. Krishnamurthy, M.Sc., D.Phil.

Scheme for Working Electron Microscope

Asstt. Physicist Shri S. G. Mehta, M.Sc.

Scheme regarding research of Insect Physiology

Insect Physiologist Dr. N. C. Pant, M.Sc. (Ag.), Ph.D. (Lond.).

Unit for Biological Testing and Certification of Insecticides

Asstt. Entomologist Shri M. G. Jotwani, B.Sc., Assoc. I.A.R.I.

Scheme for Establishing Unit for Storage Pest Ecology

Asstt. Entomologist Shri P. B. Mukherjee, B.Sc., Assoc. I.A.R.I.

Scheme for Survey of Beneficial Parasites of Pest of Agril. Crops

Asstt. Entomologist Shri A. K. Sharma, M.Sc., Assoc. I.A.R.I.

Scheme for Entomological Investigation with the help of Radioactive Isotopes

Entomologist Shri S. M. Chatterjee, M.Sc., Assoc. I.A.R.I.

Scheme for Setting up of Seed Testing Station

Entomologist Shri H. N. Batra, B.Sc. (Ag.), Assoc. I.A.R.I.

Locust Toxicology Scheme

Asstt. Toxicologist Dr. P. D. Srivastava, M.Sc. (Alld.), D. Phil. (Alld.).

Scheme for Research on Indian Honey Bee at B.S.S., PUSA

Asstt. Entomologist Shri Pritam Lall Sharma, M.Sc. (Ag.) (upto 16-8-61).

I.C.A.R. Scheme for Exploration of Toxicity Hazards

1. Asstt. Entomologist Shri Yash Pal Beri, M.Sc.
2. Asstt. Chemist Shri R. S. Diwan, M.Sc. (Tech.).

Scheme for Coordinated Plant Virus Research Diseases

Poona Centre :

1. Virus Entomologist Shri P. M. Verma, M.Sc.
2. Virus Pathologist Dr. S. P. Capoor, M.Sc., Ph.D.

Eastern Zone, Kalimpong :

1. Virus Pathologist Dr. S. P. Raychaudhuri, M.Sc., D.Phil. (Cal.), FLS, Assoc. I.A.R.I. (upto 1-8-61).
2. Virus Entomologist Shri S. N. Chatterjee, M.Sc., Assoc. I.A.R.I.

Delhi Centre :

Asstt. Virus Pathologist Shri G. P. Anand, M.Sc.

Simla Centre :

1. Asstt. Virus Pathologist Dr. B. B. Nagaich, M.Sc. (Ag.), Ph.D. (Ell.) (from 24-5-58).
2. Asstt. Virus Pathologist Shri M. L. Seth, M.Sc. (Ag.).

Scheme for Use of Atomic Energy in Plant Pathological Research

1. Plant Pathologist Shri B. S. Bajaj, M.Sc.
2. Asstt. Plant Pathologist Shri Dharam Vir, M.Sc.

Scheme for Setting up of Seed Testing Station

Plant Pathologist Dr. D. Suryanarayan, M.Sc., D.Sc. (Agr.).

Linseed Rust Scheme

Asstt. Mycologist Shri D. P. Misra, M.Sc., Assoc. I.A.R.I.

Scheme for the study of Factor responsible for change of Red Rot Fungus Flora & Allied Aspect

Mycologist Dr. B. L. Chona, B.Sc., Ph.D. (Lond.) D.I.C. (Lond.).

Scheme for Research on Fungicides at I.A.R.I.

Asstt. Plant Pathologist Dr. J. S. Grewal, M.Sc. (Ag.), D.Phil. (Alld.).

Scheme for the Appraisal of Losses due to Plant Disease

Mycologist Dr. V.V. Chenulu, B.Sc., Assoc., I.A.R.I., Ph. D.

All India Coordinated Scheme for Research on the Investigation and Control of Rust Disease of Sugarcane

Asstt. Mycologist Shri Harnek Singh Sohi, M.Sc. (Hons.).

I.A.R.I. Dispensary

Civil Asstt. Surgeon Dr. R. K. Jeerath, M.B.B.S.

VI. POST GRADUATE STUDENTS, RESEARCH FELLOWS AND HONORARY RESEARCH WORKERS

STUDENTS ADMITTED DURING THE YEAR 1961

Agronomy Division (M.Sc. course)

- | | |
|------------------------|----------------------------------|
| 1. Shri M. M. Hosmani. | 8. Shri T. S. Gopinathan Nair. |
| 2. „ G. Hunisigi. | 9. „ R. B. Patel. |
| 3. „ P. K. Jana. | 10. „ V. S. Patil. |
| 4. „ V. R. Koraddi. | 11. „ Sanni Prasad. |
| 5. „ R. S. Joshi. | 12. „ M. L. Sharma. |
| 6. „ S. K. Mukherjee. | 13. „ M. L. Malla. |
| 7. „ D. Mukhopadhyay. | 14. „ Chamnongsak Kanchanahuta.. |

Agricultural Economics (M.Sc. course)

- | | |
|-----------------------------|------------------------|
| 15. Shri T. P. Gopalaswamy. | 18. Shri S. N. Sharma. |
| 16. „ P. M. Maddal. | 19. „ B. P. Dhital. - |
| 17. „ N. S. P. Rebollo. | |

Agricultural Extension (M.Sc. course)

- | | |
|----------------------|-----------------------|
| 20. Shri B. S. Arya. | 22. Shri T. Sengupta. |
| 21. „ H. S. Arya. | 23. „ Brahmjit Singh. |

Agricultural Botany (M.Sc. course)

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|-------------------------|-----------------------------|
| 24. Shri B. K. Bhat. | 33. Shri A. Narayanan. |
| 25. „ V. George. | 34. „ M. S. Patel. |
| 26. „ K. Goswami. | 35. „ S. V. Krishna Prasad. |
| 27. „ K. I. James | 36. „ R. Naga Raja Rao. |
| 28. „ B. H. Katarki. | 37. Miss R. Pankaja Reddy. |
| 29. „ B. L. Kalu. | 38. Shri P. P. Sharma. |
| 30. „ V. V. Krishnaiah. | 39. „ G. Shivashankar. |
| 31. „ G. N. Kulkarni. | 40. „ T. Srinivas. |
| 32. „ A. K. Misra. | 41. „ L. P. Upadhyay. |

Entomology Division (M.Sc. course)

- | | |
|------------------------------|--------------------------|
| 42. Shri A. K. Bhattacharya. | 45. Miss P. T. Parvathy. |
| 43. „ J. L. Koul. | 46. Shri K. Rajasekhara. |
| 44. Miss S. Ramamani. | 47. „ A. H. Shah. |

Horticulture Division (M.Sc. course)

- | | |
|---------------------------|-------------------------|
| 48. Shri S. Bhattacharya. | 54. Shri I. Lingamuthu. |
| 49. „ N. N. Bid. | 55. „ S. S. Negi. |
| 50. „ Elias K. Chacko. | 56. „ Vidya Sagar. |
| 51. „ Amba Dan. | 57. „ B. R. Sharma. |
| 52. „ S. P. Ghosh. | 58. „ P. P. Shrestha. |
| 53. „ P. L. Kar. | |

Mycology Division (M.Sc. course)

- | | |
|----------------------------|-----------------------|
| 59. Shri M. H. Govindappa. | 63. Shri N. Rajamani. |
| 60. „ D. K. Mitra. | 64. „ K. Seshadri. |
| 61. „ Mahendra Pal. | 65. „ R. D. Sharma. |
| 62. „ V. N. Pathak. | |

Soil Science & Agril. Chemistry (M.Sc. course)

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| 66. Shri M. L. Adil. | 75. Shri S. Sambooranaraman. |
| 67. „ M. K. Badiger. | 76. „ C. L. Sanoria. |
| 68. „ Fatchlal. | 77. „ M. C. Sarkar. |
| 69. „ S. K. Kenchanagowda. | 78. „ N. J. Sawarkar. |
| 70. „ S. M. Laskar. | 79. „ P. R. Sharma. |
| 71. „ Gagan Nath. | 80. „ J. N. Verma. |
| 72. „ Ved Pal. | 81. „ G. Kasi Viswanadham. |
| 73. „ D. R. Panda. | 82. „ M. L. Pradhan. |
| 74. „ Basawan Prasad. | 83. „ Neerun Singhabootra |

*Agronomy Division (Ph.D. course) **

- | | |
|------------------------|------------------------|
| 1. Shri O. P. Awasti. | 5. Shri D. Lenka. |
| 2. „ A. Venkata Chari. | 6. „ J. C. Majumdar. |
| 3. „ P. N. Kalbhor. | 7. „ K. N. Srivastava. |
| 4. „ S. B. Kute. | 8. „ P. P. Tarahalkar. |

Agricultural Extension (Ph. D. course)

- | | |
|------------------------|--------------------------|
| 9. Shri N. K. Jaiswal. | 11. Shri P. R. R. Sinha. |
| 10. „ Y. P. Singh. | |

Agricultural Botany (Ph.D. course)

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|-------------------------------|--------------------------|
| 12. Shri A. K. Bagga. | 18. Shri S. Jana. |
| 13. „ Satish Chandra. | 19. „ T. D. Jha. |
| 14. „ S. R. Chandrasekhariah. | 20. „ R. Krishnaswami. |
| 15. „ D. C. Das. | 21. „ Bhupendra Rai. |
| 16. Miss P. A. Desai. | 22. „ R. S. Sadasivaiah. |
| 17. Shri R. Gopalakrishnan. | 23. „ R. K. Sahay. |

Entomology Division (Ph. D. course)

- | | |
|------------------------|-----------------------|
| 24. Shri S. M. Ahmed. | 28. Shri L. M. Singh. |
| 25. „ P. Dhall. | 29. „ K. R. Thakare |
| 26. „ H. L. Kulkarny. | 30. „ A. N. Verma. |
| 27. „ N. Ramakrishnan. | |

Horticulture Division (Ph. D. course)

- | | |
|------------------------|------------------------|
| 31. Miss R. D. Bamzai. | 33. Shri J. B. Chugare |
| 32. Shri H. C. Das. | 34. „ A. S. Gill. |

35. Shri P. C. Sivaraman Nair.
 36. „ R. S. Punia.
 37. „ C. B. S. Rajput.

Mycology Division (Ph.D. course)

40. Shri D. K. Chakravarty.
 41. „ A. K. Lambat.
 42. „ A. K. Mukherjee.
 43. „ Y. C. Paliwal.

38. Shri C. Sharma.
 39. „ K. R. Thimma Raju.
 44. Shri B. P. Patil.
 45. Miss V. Vijaya Rao.
 46. Shri S. Subbarayed.

Soil Science & Agril. Chemistry (Ph.D. course)

47. Shri D. L. Deb.
 48. „ H. Eshwarappa.
 49. „ S. K. Ghosh.
 50. „ N. D. Manikar.
 51. „ Surinder Mohan.

52. Shri K. S. Pharande.
 53. „ C. R. Prasad.
 54. „ B. P. Sahi.
 55. „ S. M. Umar.
 56. „ D. E. Chandool.

STUDENTS AWARDED THE POSTGRADUATE DIPLOMA IN M.Sc. & Ph.D. (1961)

Name of Student	Title of the Problem
<i>Agronomy Division (M.Sc.)</i>	
1. Shri Santosh Kumar Mukherjee	Relative efficiency of Soil and Spray application of Urca on Potato.
2. „ Nabakishore Behera	Studies on the effect of organic manures and fertilizers alone and in combination on wheat.
3. „ Shiv Nath Singh Gahlaut	Study of differential response of sugarcane varieties to doses of nitrogen.
4. „ Bichitra Bijoy Chaudhuri	Effect of different doses of nitrogen, phosphorus and potash along with different doses of farm yard manure on cauliflower.
5. „ Jagdish Chandra Majumdar	Effects of seed inoculation with three different strains of <i>Rhizobium leguminosarum</i> with and without nitrogen and phosphate fertilization on peas.
6. „ Lajpat Rai Ahuja	Response of hybrid Maize to Micro-nutrients.
7. „ Subhashchandra Bhupal Hukkeri.	The influence of varying levels of irrigation, nitrogen, phosphorus and potassium on the growth and the yield of the potato.
3. „ Damodar Lenka	Relative efficiency of soil and spray application of urca on wheat varieties.

Name of Student	Title of the Problem
9. Shri Dharmavaram Rangamannar .	Effect of different moisture regimes and Nitrogen levels of growth, yield and quality of onion.
10. „ Harish Chandra Sharma .	Control of weeds in Maize by chemical and cultural methods.
<i>Botany Division (M.Sc.)</i>	
11. „ Pralhad Dhumacharya Hukeri .	Study of inheritance of some quantitative characters in <i>Gossypium hirsutum</i> , L.
12. „ Kishorchandra Bhimbhai Desai .	Further studies on flowering and boll formation in some varieties of <i>Gossypium hirsutum</i> , L.
13. „ Hanumant Mathuji Sonone .	A study of suitability of certain hybrid strains of wheat under different environmental and cultural conditions.
14. „ Ram Nath Kaw	Study of genetic variability in Indian Barley with regard to quantitative and taxonomic characters.
15. „ Jagdish Behari Lal Mathur .	Studies on the correlation between morphological and anatomical characters and rust resistance in wheat.
16. „ A. Padmanabhan Tampi .	The effect of sowing dates on yield and its component characters in some soybean varieties.
17. „ D. K. Tirumalchar	A study of the range of varietal variation in capsaicin content in chilli (<i>Capsicum annum</i> , L.).
18. „ Pradeep Kumar Duara	Studies on the effect of genetic diversity of inbred lines in single crosses of Maize (<i>Zea Mays</i> Linn.).
19. „ Durga Charan Das	Pachytene Analysis in <i>Oryza perennis</i> Moench.
20. „ Saktisinha Jana	Induction and evaluation of polyploidy in some ornamental plants.
21. „ Chandra Mohan Pattanayak .	Evaluation of F ₃ and backcross progenies in A cross H. 14 × S.A. 594 in <i>Gossypium hirsutum</i> , L. for boll number.
22. „ Prem Swaroop Bhatnagar .	Performance of some inter-varietal hybrids in linseed (<i>Linum usitatissimum</i> L.) with reference to combining ability in respect of yield and yield contributing characters.
23. „ Kailash Chander Katyal .	Botanical Classification and Economic Evaluation of Oat varieties.

Name of Student	Title of the Problem
24. Shri Bhupendra Rai	A study of the range of variation of the factors contributing to yield in yellow sarson (<i>Brassica campestris</i> L. Var. Sarson grain).
25. „ Joginder Pal Tondon	The analysis of diallel cross with regard to various quantitative characters in wheat (<i>T. aestivum</i> L.).
26. „ Vishnoo Lockchand Asnani	Studies on general and specific combining ability of inbred lines of maize (<i>Zea mays</i> Linn.)
27. „ Kumaran Gopakumar	Pachytene analysis in <i>Oryza spontanea</i> .
28. „ Ramnarayan Raut	Mutation studies in Tomato with Particular Reference to Fruit Colour Distribution.
29. „ Govardhanam Venkata Nadhachary.	Mutation studies in Cultivated Rice.
30. „ Harindar Mohan Dani	Effect of boron on growth, composition and yield of wheat.
31. „ Gownivar Pally Prabhakara Reddy.	Studies on variability and the inter-relationship of yield determining characters in <i>Brassica campestris</i> VAR. Brown Sarson.
32. „ Md. Abdul Hakeem	Expression of Heterosis in some varietal crosses of <i>Sorghum Vulgare</i> (Pess), with respect to vegetative and growth characters.
33. „ Madhava Narashinva Koppar	Species differentiation in the genus <i>Crotalaria</i> .
34. „ Mohan Charan Patnaik	A study of heterosis in pearl millet <i>Pennisetum typhosides</i> (Burn) Staph. & Hull.
35. Miss Manorama Ramaswamy	Effect of photoperiod on growth and development of two varieties of wheat.
36. Shri Mylavaram Venkata Krishna Rao.	A study of the influence of spray application of NP and K, on tillage and Ear/Tiller ratio of 3 varieties of wheat.
37. „ Amar Singh	Studies on variability among some strains of Anjan grass (<i>Cenchrus setigerus</i> Vahl).
38. „ Pattur Ramamurti Jagadees Prasad.	Mutation studies in potato and effect of post-irradiation <i>hypoosia</i> on Chromosome breakage.
<i>Soil Science and Agricultural Chemistry (M.Sc.)</i>	
39. Miss Somnuk Viravidhaya	Determination of nitrogen and phosphorus uptake in maize and paddy crops under phosphobacterin treatment at Karnal.

Name of the student	Title of the Problem
40. Shri Sudhansu Kumar Ghosh	Nature and Genesis of Minerals in Soil Clays of some Black, Red and Laterite Soils of India.
41. „ Supada Bhiku Varade	Foliar application of urea to maize.
42. Miss Geetanjali Roy	Effect of Flooding and organic matter on the uptake of phosphorus by paddy.
43. Shri Bindeshwari Prasad Sahi	Influence of parent material on soil genesis in Himachal Pradesh.
44. „ Nand Kumar Mannikar	Comparative efficiency of some green manuring crops in bringing about the transfer of applied phosphorus from subsoil depth to surface layer (studies with p^{32}).
45. „ S. Seetharaman	Studies on some compound fertilizers with ammonium chloride.
46. „ Dipak Lal Deb	Anion unsaturation of soil and utilisation of phosphatic fertilizers by crop.
47. „ Gulabrao Shivaramrao Khanvilkar.	Effect of some moisture repellant coating materials on the storage properties of fertilizers.
48. „ Beninhally Malle Gowda Ramalingu.	Nitrogen availability and losses in water-logged conditions of Typical Indian Soils.
49. „ Bhalchandra Ganesh Apte	Manurial efficiency of superdigested compost.
50. „ K. V. Venkataraman	Rhizosphers Effects on Micro-organisms.
51. „ Mohan Krishan Sinha	Studies on Bacterial Fertilizers Microbiological Solubilization of Phosphates.
52. „ Talur Satyanarayana	Chemical and mineralogical composition of red and black soils in relation to the parent rock.
53. „ Vinayak Gopalrao Kalamkar	Correlation of soil tests with response of spinach in some of the Indian Soils.
54. „ Hari Prasad Borthakur	The effect of lime on the availability of phosphorus and nitrogen under arable and water-logged conditions in acid soils.
55. „ Suresh Kumar Ahuja	Physical Chemistry of Soil Potassium and its availability.
56. „ Chitta Ranjan Biswas	Mineralogy of some Indian soil clays in relation to their total internal surface.
57. „ Haorockcham Megharaj Singh	Autoxidised Fats as Fungicides.

Name of Student	Title of the Problem
<i>Entomology Division (M.Sc.)</i>	
58. Shri Syed Musthaq Peeran . . .	Relative toxicity of insecticidal films to the Cigaratte Beetle <i>Lasioderama Serricorne</i> (Fabr).
59. Miss Gidla Pushpa Veni . . .	Studies on Indian Sphecoidea (Hymenoptera).
60. Shri E. Sukumaran Onnithan . . .	Relative Efficacy of some Fumigants against different States of the Rice Moth <i>Corcyra cephalonica</i> Stainton.
61. „ Om Parkash Bhalla . . .	Ecology of <i>Glyptomorpha</i> (<i>Stenobracon</i>) Deesze (CAM). A Parasite of Sorghum and Maize Borer.
62. „ Parshuram Dhall . . .	Persistence of insecticide residue on Bhindi plant against the first instar caterpillars of <i>Earias Fabia</i> Stoll.
63. „ Syed Mohammed Ahmed . . .	Studies on Indian Carabide (Coleoptera).
64. „ Tarini Charan Deka . . .	Studies on the interspecific competition between <i>Bracon gelechia</i> Ashmead and <i>Bracon Brevicornis</i> Nesmael (Broaconidae: Hymenoptera).
65. „ Pranab Roy . . .	Nutritional studies on <i>Tribolium castaneum</i> (Herbst) with reference to the lipid requirements.
<i>Horticulture Division (M.Sc.)</i>	
66. Shri Janak Dev Shakya . . .	Taxonomical studies in some important varieties of mango (<i>Mangifera indica</i> L.).
67. „ Imtiaz Rasul . . .	Taxonomical studies on some important species and varieties of citrus of Assam.
68. „ Inderjeet Singh Yadav . . .	Studies on morphology, floral biology and cytology of peach (<i>Prunus persica</i> Bastch) grown under sub-tropical conditions.
69. „ Rajinder Singh Punia . . .	Studies on inheritance of certain characters in Tomato (<i>Lycopersicon esculentum</i> Mill).
70. „ Har Charan Dass . . .	Studies on floral biology, floral anatomy and cytology of phalsa (<i>Grewia asiatica</i> Lindl)..
71. „ Chandra Bhan Singh Rajput . . .	Studies on morphology and floral biology of loquat (<i>Eriobotrya japonica</i> Lindl.).
72. „ Ramesh Chandra Khanna . . .	Fruiting in relation to growth and seasonal changes in grape fruit (<i>Citrus paradisi</i> Macfadyen).

Name of Student	Title of the Problem
73. Shri Hemendra Nath Samaddar	Fruiting in relation to growth in sweet lime <i>Citrus limettioides</i> Tanka.
74. „ Kumud Rajan Sarkar	Propagation studies in citrus with special reference to rooting of cuttings and polyem- bryony.
75. „ Kartar Singh Arora	Study of fruit drop in mango (<i>Mangifera indica</i> L.)
76. „ Mani Singh Leisram	Studies on the preservation of mandarin orange (<i>Citrus reticulate</i> Blanco) Juice.
77. „ P. K. Gopalakrishnan	Studies on sex expression, sex ratio and fruit development as affected by plant regulators in watermelon (<i>Citrulus vul- garis</i> Schrad).
78. „ Hardev Singh Sangha	Studies on hylerid Vigour and its utiliza- tion in tomato (<i>Lycopersicon esculentum</i> Mill).
79. „ Surendra Kumar Chopra	Fruiting in relation to growth and blossom bud differentiation in Mandarin orange (<i>Citrus reticulata</i> Blanco).
80. „ R. Rajendran	Studies on the exploitation of hybrid vigour in bottle gourd (<i>Lagenaria siceratia</i> Standl).
81. „ Kammasandra Subbaiah	Fortification of fruit products with vit. C.
82. „ Hardiyal Singh Verma	Studies on external morphology. Pollina- tion and cytology of plums grown under sub-tropical conditions.
83. „ Om Prakash Sehgal	Studies on Morphology and Blossom Bio- logy in Guava (<i>Psidium guajava</i> L.).

Mycology & Plant Pathology Division (M.Sc.)

84. Shri Feera Paneni Raghavendra Rao	Diplodia die-back of roses.
85. „ Dilip Kumar Chakravarty	Survey of Fruit and Vegetable diseases in Delhi markets.
86. „ Yogesh Chandra Paliwal	Inhibition of Sun-hemp mosaic virus by plant extracts and ultra-violet and gamma radiations.
87. „ K. Janardanan Pillai	Studies on the root-knot nematodes of vegetable crops.
88. Kumari Bineeta Chatterjee	Nutritional requirements and pathogenesis of loose smut of wheat (<i>Ustilago tritici</i> (fers) Rostrup.

Name of the student	Title of the Problem
89. Shri Katta Ramachandra Reddy	Studies on mosaic diseases of vegetable Marrow (<i>Cucurbita Pepo</i> L.).
90. „ Tarapada Bhowmik	Studies on maize rust (<i>Puccinia sorghi</i> Schw).
91. „ Tapan Kumar Kar Choudhury	Studies on the seed-born <i>Alternarias</i> pathogenic to vegetables in India.

Agronomy Division (Ph. D.)

92. Shri Chit Ranjan Kumar Prashar	A study of inter-relation of irrigation, nitrogen, phosphorus and potassium on plant growth and yield of wheat under intensive system of cropping.
93. „ Madan Mohan Prasad Shrivastava.	Relative efficiency of spray fertilization and soil application of major plant nutrients for wheat and their evaluation by plant tissue tests.
94. „ Chintamaneni Syamasundara Rao.	Effectness of audio-visuals in diffusing information and acceptance of approved agricultural practices.

Botany Division (Ph.D.)

95. Shri Chittaranjan Bhatia	Evaluation of the utility of radiation induced mutations in wheat breeding.
96. „ Kuchimanchi Satyanarayana Murty.	Analysis of the effect of soil drought on grain setting in wheat.
97. „ Popuri Kodanda Ramaiah	Analysis of tillering behaviour of three varieties of wheat.
98. Kumari Satya Nirula	The effects of ultraviolet pre-treatment and of some biological factors on the frequency and spectrum of mutations induced by radiations in wheat and sorghum.

Soil Science and Agricultural Chemistry (Ph.D.)

99. Shri Krishna Kant Vyas	Spray fertilization of phosphatic fertilizer on a number of crops versus normal soil application.
100. „ Shridhar Punjaji Gawande	Pedological study of development of associated soils in Toposequence.
101. „ Ayalasomayajula Sankaram	Rhizosphere effects on soil micro-organisms.

Entomology Division (Ph.D.)

102. Kumari Nandini Sadanad Khot	Studies on Indian Mites with special reference to the super-family Erythroidea.
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Name of Student	Title of the Problem
<i>Horticulture Division (Ph.D.)</i>	
103. Shri Shyama Nand Singh	Effects of various methods of plant regulator application on growth and fruiting in Tomato (<i>Lycopersicon esculentum</i> Mill).
104. „ Ram Bahadur Sinha	Fruiting in relation to growth in Sweet Orange (<i>Citrus sinensis</i> Osbeck).
105. „ Surrinder Singh Randhawa	Studies on fruit set and drop in citrus with special reference to Mandarin (<i>Citrus reticulata</i> Blanco).
<i>Mycology & Plant Pathology Division (Ph.D.)</i>	
106. Shri K. S. Mahadeva Sastry	(1) Effect of host plant nutrition on multiplication, concentration and movement of <i>Sunnehemp</i> mosaic virus. (2) Effect of host plant nutrition on the susceptibility of tobacco plants to infection with tobacco leaf curl virus.
107. „ Man Mohan Singh Manocha	Physiology of parasitism, with special reference to the factors affecting the virulence of light & dark isolates of <i>Colletotrichum falcatum</i> went, the causal organism of red rot of Sugarcane.
108. „ Bimalendu Ganguly	(a) Symptoms, expression, host range, physical properties, effect of environment and nutrition on incubation period and concentration of the virus. (b) Analysis of factors underlying the resistance of chilli varieties, Puri Red and Puri Orange, tomosaic virus.
109. „ C. S. Krishna Moorthy	Studies on Tobacco Powdery Mildew disease.
110. „ Pritam Singh	Further studies on "Bulbiformin", an antibiotic produced by bacillus subtilis chon. emend, prszmowski and its uses in plant disease control.

SHORT COURSE STUDENTS AND HONORARY RESEARCH WORKERS TRAINED DURING THE YEAR

A short term refresher course in Agronomy was held at the Division of Agronomy for the benefit of Agricultural Teachers. The following Agricultural Teachers attended the training course :—

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| 1. Shri D. P. Patel. | 4. Shri A. M. Deshpande. |
| 2. „ C. M. Patel. | 5. „ J. R. Kakde. |
| 3. „ C. M. George. | 6. „ N. T. Badhe. |

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| 7. Shri P. G. Muddaiah. | 21. Shri Kanwar Singh. |
| 8. „ N. T. Sarnaik. | 22. „ Balkar Singh. |
| 9. „ S. A. Hosamani. | 23. „ G. P. Trivedi. |
| 10. „ Wasi Hassam. | 24. „ R. K. Patel. |
| 11. „ K. N. Srivastava. | 25. „ N. S. Katole. |
| 12. „ Din Dayal Mahan. | 26. „ V. V. Sharda. |
| 13. „ G. B. Singh. | 27. „ R. C. Mehta. |
| 14. „ P. C. Jaiswal. | 28. Dr. M. R. Bajpai |
| 15. „ Maharaj Singh. | 29. „ Gajadhar Singh. |
| 16. „ Satya Des Singh. | 30. Shri J. P. Patel. |
| 17. „ N. Mookerjee. | 31. „ M. K. Misra. |
| 18. „ K. Jaganathan. | 32. „ K. S. Cheema. |
| 19. „ A. Kandaswamy. | 33. „ G. L. Mishra. |
| 20. „ P. K. Panigrahi. | |

A short course training in Maize Breeding and Seed Production was held at the Division of Botany. The following candidates attended the training programme :—

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| 1. Shri C. V. Raj. | 3. Shri A. K. Bose. |
| 2. „ S. K. Vasal. | 4. „ W. K. Nichal. |

A short course training in Soil Survey was conducted at the Division of Soil Survey. The following trainees attended the training course :—

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| 1. Shri B. K. Mathur. | 6. Shri V. B. Nair. |
| 2. „ Krishen Rao. | 7. „ Y. S. Sharma. |
| 3. „ C. Ratnam. | 8. „ S. C. Acharya. |
| 4. „ D. M. Samuel. | 9. „ N. L. Chakrabarty. |
| 5. „ J. L. Mithrachaly. | |

A short course training in Seed Testing was held at the Division of Botany for the Seed Testing Officers and Seed Development Officers in two batches. The following attended the programme :—

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| 1. Shri K. K. Mandloi. | 8. Shri H. V. R. Iengar. |
| 2. „ V. N. Khot. | 9. „ S. N. Malik . |
| 3. „ K. B. Nigam. | 10. „ V. P. Sobti. |
| 4. „ R. C. Srivastava. | 11. „ P. S. Sabsena. |
| 5. „ U. N. Mukherjee. | 12. „ A. N. Asthana. |
| 6. „ E. A. Khan. | 13. „ M. A. Q. Khan. |
| 7. „ M Ranga Reddi. | 14. „ A. Subba Raju. |

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| 15. Shri M. A. Haider. | 18. Shri B. K. Sharma. |
| 16. „ A. Subramaniam. | 19. „ P. D. Singh. |
| 17. „ V. Venkata Subramanian. | 20. „ B. Nigam. |

SHORT COURSE TRAINING FACILITIES ARRANGED IN THE DIVISION.

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|------------------------|---|---|---|------------------------|
| 1. Shri K. P. Pillay | . | . | . | Division of Botany. |
| 2. „ R. N. Srivastava | . | . | . | Ditto. |
| 3. „ B. L. Tikkoo | . | . | . | Ditto. |
| 4. „ Shankar Pal Singh | . | . | . | Division of Chemistry. |

